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DOT/FAA/SE-90-1
DOT/FAA /CT-TN90/01

NAS System Engineering Service
Washington, D.C. 20591

National Airspace System (NAS) Software Life Cycle Management Study

March 1990

Final Report

US Department of Transportation
Federal Aviation Administration

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Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
DOT/FAA/SE-90/1		

4. Title and Subtitle	5. Report Date
NATIONAL AIRSPACE SYSTEM (NAS) SOFTWARE LIFE CYCLE MANAGEMENT STUDY	March 1990
	6. Performing Organization Code
7. Author(s) Technology Planning, Inc.	8. Performing Organization Report No. DOT/FAA/CT-TN90/01
9. Performing Organization Name and Address Technology Planning, Incorporated 51 Monroe Street, Suite 102 Rockville, Maryland 20850	10. Work Unit No. (TRAIS)
	11. Contract or Grant No. DTOS59-88-C-00064, T.O. 0011
12. Sponsoring Agency Name and Address U.S. Department of Transportation Federal Aviation Administration System Engineering Service Washington, DC 20591	13. Type of Report and Period Covered Final Report
	14. Sponsoring Agency Code ASE-200 transferred to ASE-500

15. Supplementary Notes

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16. Abstract

In implementing FAA-STD-026 (based on DOD-STD-2167A) for acquiring NAS software and adopting the Ada Programming Language as the single high order language for NAS, several issues were raised pertaining to the differences in software development, testing, and maintenance practices between the NAS acquisition and operations support organizations. This report identifies and documents some of the deficiencies with respect to the existing process and guidelines used to acquire and maintain NAS software and recommends an action plan to address the identified deficiencies.

In addition, it presents an overview (list of products and activities) of the NAS System Life Cycle management process within the context of a major systems acquisition, as described by FAA Orders 1810.1 and 1800.8. The process is applicable to non-major systems as well.

17. Key Words	18. Distribution Statement
NAS System Life Cycle Software Engineering NAS Software Engineering Software Life Cycle	Document is on file at the Technical Center Library, Atlantic City International Airport, NJ 08405

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	113	

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

EXECUTIVE SUMMARY

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1.0 INTRODUCTION

1.1 BACKGROUND

The Federal Aviation Administration (FAA) is involved in a major modernization and expansion of the National Airspace System (NAS) in order to meet future requirements and demands. The Advanced Automation System (AAS) is estimated to contain two million lines of code. The primary AAS language is Ada. While the AAS is the largest of the NAS subsystems, many other subsystems such as Data Link, Mode-S, NADIN II, CWP, and AERA are software intensive as well. More and more NAS functions will be automated and software will be increasingly depended upon.

Key to the NAS modernization initiative is the acquisition of software to support the intended services. Considering the complexity of the effort, it is imperative that the FAA methodology used to acquire and maintain NAS software be documented to provide a common perspective for planning, requirements analysis, system design, program development and implementation, test and evaluation, deployment, and maintenance.

1.2 SCOPE, OBJECTIVES AND GOALS

The System Engineering and Program Management Office, System Design and Configuration Management Division (ASE-200), is responsible for developing and maintaining the technical standards used in acquiring NAS subsystems. To date, FAA has standardized on a software development standard, FAA-STD-026 (based on DoD-STD-2167A), and on the Ada Programming language. In implementing these standards several issues have arisen pertaining to the differences between software development, testing, and maintenance practices between the NAS acquisition and maintenance organizations.

To clarify and address these issues the FAA tasked Technology Planning Incorporated (TPI) to review the existing FAA software policies, orders, standards, process, and procedures which are used by the FAA for NAS software acquisition, maintenance, data and documentation management. The objectives were to:

1. Identify current deficiencies, omissions, and conflicts with respect to these guidelines;

2. Review specific NAS Plan subsystems in terms of the proposed end-state software, data engineering environment, software development methodology, general implementation and maintenance strategy;

3. Document deficiencies and make recommendations; and

4. Assist in the preparation of a NAS System-level Plan to address the identified deficiencies.

As a result of accomplishing the above objectives, the following longer range goals can be initiated.

Goal 1

Improve the process of constructing quality software.

Goal 2

Reduce the risk factors associated with building systems. The risk factors include technical, schedule, cost, operational and support areas.

Goal 3

Heighten the awareness and increase the involvement of management and other appropriate staff with the software acquisition process.

Goal 4

Cultivate the development of software engineering strength within FAA.

1.3 TERMINOLOGY

Throughout this report the word "guidelines" is used to indicate any of the standards, orders, policies or procedures used by the FAA for NAS software acquisition.

1.4 METHODOLOGY

In order to adequately address Software Acquisition by the FAA, the acquisition of software must be looked at in the larger context of the NAS System Life Cycle and must consider the system level aspects of the life cycle which directly influence or are influenced by software.

The methodology used in performance of this task includes four steps:

1. Development of a Data Collection Instrument which was used during interviews with FAA personnel who are responsible for some aspect of software within some phase of the NAS System

Life Cycle;

2. Data collection which included the personnel interviews and reviews of selected policies, orders, standards and guidelines;

3. Analysis of the data collected;

4. Development of conclusions and recommendations which have resulted in a plan of action for the FAA.

The following organizations participated in the interviews for this task:

AAF-4, AAP-120, AAP-220, AAP-320, AAP-400, AAT-14, ACD-340, ACD-350, ACN-110, ACN-130, ACN-210, ACN-310, ACS-320, ADS-120, AHT-400, AHT-500, ALG-410, AMC-300, AOR-110, APS-300, APS-500, ASA-6, ASA-130, ASA-210, ASM-140, ASM-160, ATR-210, ATR-250, LOGICON.

2.0 OVERALL ASSESSMENT

One of the most common problems facing government and private organizations is the transition to a modern and effective software engineering methodology for creation of software systems, acquisition of software systems, or both. This problem is addressed in depth in the literature ([AFSB89], [AFSC89], [NASA89], and [PRESS88]) but still remains a problem. In these and other studies the fundamental approach has been a four stage approach consisting of:

1. Assessment of current practices;

2. Development of a strategic plan for the transition to improved practices;

3. Implementation of the plan;

4. Evaluation of the success or failure of the plan.

TPI has performed the first portion of step 1 by performing a qualitative analysis of the FAA's software acquisition process. The findings of this analysis can serve as the basis for identifying the remaining activities required to improve the FAA's software acquisition process.

The results of TPI's assessment are summarized as follows:

1. There is a lack of adequate commitment to the software aspects of FAA projects;

2. There is not enough up to date software expertise within the FAA;

3. Some problems in software acquisition are due to the FAA organizational structure which artificially separates hardware, software and systems engineering activities;

4. There are problems that are the result of inadequate, missing, or poorly understood FAA standards, guidelines and orders associated with the software acquisition process.

5. There is a lack of involvement of software maintenance people during the program definition and software acquisition phases.

Although the report that TPI produced, detailing the findings of the assessment, reports several other problems, analysis shows that almost all the problems can be traced back to these four basic points.

3.0 RECOMMENDED COURSE OF ACTION

To continue with the approach outlined in Section 2.0 above, TPI recommends the following course of action. Although the activities detailed imply a sequential order, there is room for parallel activities to occur. Some of these activities are required to be performed in the near term, while others may be performed in the range from medium to long term.

While a complete implementation of all the recommendations is encouraged, budget considerations may dictate that selected parts of the recommendations be deferred to a later time. This is entirely possible due to the nature of the problems. There will be a loss of the synergistic effect of implementing all recommendations as one program plan. Due to the complexity of the software acquisition process, it is expected that a complete program to improve the process will take several years to accomplish.

The following activities have been identified to address the approach and the problems cited in the preceding section. Each activity supports the longer range goals described in Section 1.2. The predominant goal for the activity is listed along with a brief explanation.

3.1 ESTABLISHING AN ADEQUATE SOFTWARE COMMITMENT

The FAA needs to establish a clear and firm commitment to dealing with software issues in FAA projects. Such a commitment consists of: (1) allocation of resources and funds to improve the process

and staff capabilities: (2) establishment of additional and enhanced software policies; (3) participation with other organizations dealing with the same issues; and (4) encouraging the involvement of senior management. This activity supports Goal 3 by elevating the level and degree of attention given to software projects.

3.1.1 Software Policy Statement

The FAA needs to develop a comprehensive software policy statement outlining the goals, commitment, and rules pertaining to software systems acquisition. This software policy statement will be used to perform evaluations of FAA projects and also to evaluate technologies, tools, and FAA guidelines pertaining to software projects. Such a policy will be coupled with improved guidelines, standards, and orders.

Because of poor experiences with past FAA projects, most projects that have a significant software component should be considered high risk projects. The overall policy statement will require a software risk assessment and risk management plan as an integral part of these projects. This activity supports Goal 2 by providing a method for evaluating high risk projects during the early phases of the software acquisition life cycle.

3.1.2 Establishment of Technical Support Groups

The FAA needs to establish agency-wide support groups dealing with major software issues. Such groups will both support projects and also serve as review and evaluation groups for project activities. They will be available upon request to assist a project with project definition and initiation activities. These groups will serve as the focal points for infusing software technology into the FAA. They will interact with industry (especially contractors), academia, and other government agencies dealing with the same issues (e.g., DoD, NASA). These groups will support the infusion of software skills into the FAA staff and projects through such activities as: training, workshops, symposia, and forums.

It is anticipated that these groups will be small in size, between 3 and 7 persons, and that these groups will report to a high enough management level to firmly establish the validity of their missions.

3.1.2.1 Software Process Support Working Groups - These groups will deal with the overall software process including guidelines, standards, and orders as well as with software project management. These groups deal primarily with software project management rather than specific technologies. Software quality assurance and

software productivity also fall under these groups. These groups are intended to be temporary in nature and to focus on one software task at a time in order to resolve immediate issues or concerns. This activity supports Goal 1 by providing a feedback loop during the software construction process.

3.1.2.2 Software Technology Support Group - This group will deal with specific software technologies and tools, as well as provide overall guidance to the working groups discussed above. This group's charter is to identify those technologies, both available and emerging, that are applicable to the FAA's environment. The services of this group would be provided on a request basis and would be available as an on-going support function. Further, this group will be responsible for the eventual incorporation of the appropriate technologies into the FAA environment. This activity supports Goal 1 by providing the technologies and tools necessary for the development and maintenance process.

3.2 IN-DEPTH TECHNICAL ASSESSMENT OF FAA SOFTWARE CAPABILITIES

Although a qualitative assessment of the FAA's software acquisition process and maintenance has already been performed by TPI, an in-depth quantitative assessment needs to be performed to guide any corrective action. For example, an assessment similar to those presented in the literature ([HUMP87] and [PRESS88]), which addresses the software engineering environment and software management activities, needs to be tailored for the FAA. Such an assessment will evaluate both: (1) the technology present within the FAA and also (2) the software process itself. This study will involve a comprehensive survey/skills profile inventory of software engineering skills present within FAA personnel. TPI's initial study identified a lack of up to date software skills within the FAA as a serious problem. This follow-on assessment will quantify the skills currently present within the FAA and identify precisely those areas where skills are lacking.

3.2.1 Software Process Assessment

A software process assessment evaluates the current practices with respect to those tools, methods, standards, and processes used by the software engineers in performance of these assignments.

Performing a software process assessment will evaluate the FAA's software process for acquisitions and maintenance against the recommended practices established within the software engineering community. Areas lacking adequate emphasis along with the skills necessary to pro-vide that emphasis will be identified. Although the FAA's software acquisition and maintenance needs are similar to other organizations, some deviations from the normal practices are

expected and acceptable. The framework for evaluation of the FAA's process should be extended to also evaluate the various contractors supporting the FAA's projects. This activity supports Goal 1 by establishing and refocusing the software process for acquisitions and Goal 2 by reducing the exposure for FAA by identifying risks early in contractor's projects.

3.2.2 Software Technology Assessment

Unlike the previous software process assessment that deals with steps and phases of a software project life cycle, this software technology assessment deals with evaluating the details of each step in the life cycle. For example, the previous assessment concerns itself with the existence of a coding standard while this step will evaluate the quality of such a standard.

This step will also perform an inventory of the software skills of the FAA staff and compare them against the skills identified by the process assessment as necessary for the various software engineering roles (i.e. manager, analyst, designer, coder, tester). This activity supports Goal 4 by providing a skill inventory for software engineers. The skill inventory would provide the basis for a professional development plan for each person.

3.3 OVERCOMING ORGANIZATIONAL BARRIERS

The management within the FAA needs to recognize and acknowledge that the NAS life cycle software process has difficulties which are associated with the current organizational structure. The hardware, software, and systems engineering activities are, in most cases, separated due to organizational decisions. This separation causes daily coordination problems for those personnel involved in these engineering activities. Lack of appropriate coordination leads to incorrect solutions with respect to requirements definition, project implementation, system integration and post-deployment support.

Policies and procedures which overcome the organizational barriers need to be implemented and rigorously enforced by all levels of FAA management. Such policies will consider: (1) increasing awareness of FAA personnel with respect to the entire NAS life cycle's products, reviews, and activities; (2) containment of life cycle costs as the responsibility of all organizations who have any level of involvement in the NAS system life cycle; (3) smooth transition procedures; (4) early consideration of the needs of all organizations (during project definition); and (5) high level commitment to enforcement of these policies. This activity supports Goal 2 by providing management with estimated cost and schedule risks for each project.

3.4 DEVELOPMENT AND IMPLEMENTATION OF A STRATEGIC PLAN FOR IMPROVING THE NAS SYSTEM LIFE CYCLE

This plan will identify the steps required to improve the acquisition of software systems within the FAA. It will identify activities such as: (1) improvements to FAA standards, orders, and guidelines; (2) establishment of a software project and system engineering curriculum; (3) improvements to the requirements determination phase of the life cycle; and (4) improvements to the the phase transitions during the life cycle. The Strategic Plan for Improving The NAS System Life Cycle will consist of three major activities:

1. Software technology transfer into the FAA;

2. Improvements to the software process through revisions of FAA standards, guidelines, and orders;

3. Continued evaluation of the software acquisitions process and software productivity.

When the plan is completed, a cost-benefit analysis will be performed to determine the implementation priority for the various aspects of the plan. This activity supports Goal 1 by focusing, monitoring and re-tuning the software acquisition process.

3.4.1 Software Technology Transfer

The transfer of software technology into the FAA involves two areas: training and support systems.

3.4.1.1 Training - The strategic plan will first develop a software engineering education curriculum that covers all aspects of software education. Such education will consist of inhouse courses and seminars, off-site commercial offerings, educational support for staff members, and sponsoring of relevant workshops and symposia. The separate training needs of management, technical staff, and project specific requirements will be identified and accommodated by the proposed curriculum. The various roles (analyst, designer, coder, tester) identified in the software process assessment will serve as one of the inputs to this process. This activity supports Goal 4 by assisting with the development of a curriculum to support the technical growth of staff.

3.4.1.2 Tool and Support Systems - Available technological advances include software tools as well as techniques. The strategic plan will identify a means of evaluating software tools and environments that would prove beneficial to the FAA and then

provide a plan for making these tools and environments available within the FAA. In some cases, evaluation experiments, perhaps involving real projects, will be performed to assess the value of these tools. This activity supports Goal 4 by evaluating the tools needed for staff involved with the software acquisition process.

3.4.2 Improving the Software Process Through Standards, Orders, and Guidelines

While many of the FAA's standards, orders, and guidelines are currently adequate, several problems were evident during TPI's initial assessment. The strategic plan will outline how the missing and inadequate standards are to be improved. The software process assessment may identify additional missing standards, orders, and guidelines. The plan will also address how appropriate information concerning FAA standards, orders and guidelines is to be disseminated to the FAA staff. The plan will also address by what process the standards, orders, and guidelines will be kept current. This activity supports Goal 1 by supporting the improvement, specification and use of standards, orders and guidelines and Goal 3 by elevating the software process to the attention of management.

3.4.2.1 Improvement to Standards, Orders, and Guidelines - Several FAA and other standards, orders, and guidelines were identified as causing difficulties with NAS software acquisition. FAA-STD-026 and DoD-STD-2167A were foremost in this area. The plan will identify the strategy for updating or replacing some standards with more effective standards. DoD-STD-2167A is now an accepted standard throughout the government. However, no consistent set of guidelines for tailoring 2167A and for using 2167A for maintenance operations are available. The plan will include an activity to provide support and guidance for the use of DoD-STD-2167A within the FAA framework. The plan will also direct the development of a strategy for the retrofitting of standards, for purposes of maintenance, where appropriate. Others in the software engineering field have reported success with retrofitting a tailored version of DoD-STD-2167A for purposes of software maintenance [KEMP88] to projects not originally using 2167A. The strategic plan will address such issues since maintenance was identified as a problem area within the FAA.

3.4.2.2 Specification of FAA Standards, Orders, and Guidelines - The plan will address the improvement and dissemination of guidelines for using the standards, orders, and guidelines within the FAA projects. It should be clear to the staff which standards, orders, and guidelines must be applied to their project and these rules should be enforced. Of course waivers are possible, but the rules should be consistently applied across FAA projects. One of

the recurring themes found in the use of standards outside the FAA is the use of tailoring and waivers. Properly used, this can prevent the misapplication of standards.

3.4.2.3 Improvement of the Use of FAA Standards, Orders, and Guidelines - After the FAA's standards, orders, and guidelines have been strengthened, there must be some mechanism for distributing this information to the FAA staff. The strategic plan will identify methods of disseminating information about FAA standards, orders, and guidelines to appropriate FAA staff members.

Possible methods for providing such distribution might include: training courses; creation of an on-line database system relating the stages of the NAS life cycle to appropriate FAA standards, orders, and guidelines; development of quick reference charts; and development of a software manager's handbook providing further explanation concerning the use of FAA standards, orders, and guidelines in relation to the NAS life cycle.

Another way to improve the effective use of the standards is to ensure that the procurement guidelines for software acquisition incorporate these new standards.

3.4.3 Evaluation

Finally, the strategic plan will direct the evaluation of current and existing software practices within the FAA. This involves the establishment and specification of software program management and engineering metrics based on the FAA Software Policy Statement mentioned in Section 3.1.1 of this summary. That will provide a way of measuring whether or not the expectations are being met. As the plan is implemented, the degree of success or failure can be determined by re-evaluating the FAA's software activities and analyzing the actual results against the expected results.

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1.0 INTRODUCTION

1.1 BACKGROUND

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To clarify and address these issues, the FAA has tasked Technology Planning Incorporated (TPI) to review the existing FAA software engineering process, standards, policies, procedures and orders which are used by the FAA for NAS software acquisition, maintenance, data and documentation management. The objectives are to: (1) identify current deficiencies, omissions, and conflicts with respect to these standards, policies, procedures and orders; (2) review specific NAS Plan subsystems in terms of the proposed end-state software, data engineering environment, software development methodology, general implementation and maintenance strategy; (3) document deficiencies and make recommendations; and (4) assist in the preparation of a NAS System-level Plan to address the identified deficiencies.

As a result of accomplishing the above objectives, the following long range goals can be initiated.

Goal 1

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Goal 2

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Cultivate the development of software engineering strength within FAA.

1.3 TERMINOLOGY

Throughout this report the use of the word "guidelines" is used to indicate any of the standards, orders, policies or procedures used by the FAA for NAS software acquisition.

2.0 METHODOLOGY

In order to adequately address Software Acquisition by the FAA, the acquisition of software must be looked at in the larger context of the NAS System Life Cycle and must consider the system level aspects of the life cycle which directly influence or are influenced by software.

The methodology used during Task Order 0011 is described in the following paragraphs and includes four steps:

(1) development of a Data Collection Instrument,

(2) data collection,

(3) analysis of the data collected,

(4) development of conclusions and recommendations which result in a plan of action for the FAA.

2.1 STEP 1 - DATA COLLECTION INSTRUMENT

The Data Collection Instrument contains a list of questions to be used during interviews, a NAS System Life Cycle definition, and a list of the current FAA standards, FAA orders, MIL standards, and DoD standards believed to be in use by the FAA for software acquisition. This instrument will be updated and modified as required during the interview process. The life cycle definition has been updated since delivery of the Data Collection Instrument and is shown in Figure 1-1 and expanded in Appendix E.

Also as part of step one, a memo was written and sent to all concerned service level managers within the FAA, requesting names of persons to be interviewed during step two.

2.1.1 NAS System Life Cycle

A brief description of the various phases of the NAS System Life Cycle as defined for this report is as follows.

(1) Requirements Determination - This consists of two distinct phases, Concept Definition and Validation and Program Definition. The Concept Definition and Validation phase encompasses all of the FAA R,E&D activities and results in initial product specifications which are input to the Program Definition phase. During Program Definition, the Statement of Work, the System/Project/Program Specifications and the Request for Proposal are finalized.

(2) Acquisition - This consists of eight sub-phases. The Project Initiation phase incorporates the initial activities of a program. These include contract negotiations, finalization of the requirements definitions, and production of initial management and planning documentation by the contractor. Activities during this phase must set the stage for the follow-on phases with respect to how the FAA and contractor will manage and control the program.The other seven phases of acquisition are the standard analysis, preliminary and detailed design, development, and the three testing phases.

(3) Operational Support - This phase covers the transition of the product from development into operational use and includes two sub-phases, Operational Transition and Post Deployment Support. The Operational Transition phase includes those testing activities conducted by both the FAA end users and the contractor which assure the readiness of the product for deployment. The Post Deployment Support includes the on-going maintenance and enhancement activities which assure continuing operation of a product over many years of service.

2.2 STEP 2 - DATA COLLECTION

Data collection involved reviewing the documentation and conducting interviews with FAA personnel.

2.2.1 Documentation Review

The documentation reviewed and reported on is listed in Appendix A of this report. Other references used in performance of this task are listed in Appendix F.

In developing the list of guidelines for review, a broad list of FAA guidelines were initially reviewed to determine whether they were used for NAS software acquisition and software management. The number of guidelines was reduced to those listed in Appendix A. Because of time constraints associated with performing this task, the selected guidelines were categorized as to whether they were considered major or not major in terms of their importance to NAS software acquisition and software management. Next the guidelines were reviewed according to a set of criteria, as discussed below, with more emphasis given to the major guidelines.

To properly perform the guideline evaluation process, a set of evaluation criteria were established. These criteria were prioritized to reflect their importance to the review process. The following evaluation criteria were used in the review of the FAA

standards and orders. They are listed in order of decreasing priority.

Evaluation Criteria	Comment
Completeness	Are all required aspects of the software development process covered?
Correctness	Are the aspects of the software development process in conformance to guidelines?
Consistency	Are the aspects of the software development process covered in the same way within each document and throughout the various documents?
Clarity	Are the guidelines and instructions concise, understandable, and self-contained?
Traceability	Does the guideline support the traceability of the quality, function, and characteristic of an item throughout the life cycle?
Effectiveness	Is the guideline feasible for supporting implementation on FAA projects? Will the process produce the products needed to manage the acquisition and assure the quality and correctness of the software?
Flexibility	Is the guideline adaptable to the variety of projects and approaches that will be encountered by the FAA?
Currency	Does the guideline reflect modern software engineering practices?

The review was performed using a multi-pass review process. During pass 1, the effort concentrated on reviewing each guideline on an

individual (i.e., stand-alone) basis. During pass 2, the documents were reviewed to evaluate the consistency and completeness between the various guidelines.

The first output of the reviews is the summary report in Paragraph 3.1.1 of this report. The summary provides a general evaluation of the guidelines and an overview of the consistency and completeness between the guidelines. The second output of the reviews is Appendix B which provides more detailed information concerning the individual guidelines that were reviewed.

2.2.2 Personnel Interviews

The FAA personnel being interviewed are from a variety of organizations which have responsibilities within the phases of the NAS System Life Cycle. The organizations included AAP, ASA, ADS, APS, ASM, ATR, ALG, AHT, ACD, AOR, ACN, AAT, AMC, ACS, AAF, and LOGICON.

The Data Collection Instrument from Step 1 was used during the interviews to guide the process and to enable organization of the answers. As the interviews progressed, the instrument was modified as some questions were found to be inadequate or required more detailed information than the interviewees were prepared to answer given the nature of the interview process.

The results from the interviews were then summarized and the details were collected in Appendix C.

2.3 STEP 3 - DATA ANALYSIS

The data analysis involves coordination of the information collected during the document reviews and the interviews. Some of this information will be organized using the NAS system life cycle as the guiding tool. That is, the information will be categorized as to the life cycle phase, product, action, or review that it affects. This categorization will then lead to the last step of drawing conclusions and making recommendations.

Appendix D is a table which lists the life cycle products, actions, reviews and other relevant software engineering topics and shows the guideline which is the governing document with respect to that topic. There may be more than one governing document as the Appendix shows. The Appendix does not attempt to list every document which references that topic. Creation of such a database is a recommended action for the FAA.

Appendix E is the Expanded NAS System Life Cycle which itemizes all products, reviews and actions which may apply to each of the phases and sub-phases of the life cycle. The items within this Appendix

are the result of the document reviews by TPI. This expanded life cycle represents the picture found within the current FAA NAS policy and process. That is, all of the documents, reviews, and actions itemized were found listed in some FAA Order or standard. This life cycle must be tailored for each NAS project.

2.4 STEP 4 - CONCLUSIONS AND RECOMMENDATIONS

The conclusions were then drawn and itemized. The final recommendations will be in the form of an action plan for the FAA.

1.0 REQUIREMENTS DETERMINATION

1.1 CONCEPT DEFINITION AND VERIFICATION (R,E&D)

1.2 PROGRAM DEFINITION (MSA: REQUIREMENTS DEFINITION)

2.0 ACQUISITION

2.1 PROJECT INITIATION (MSA: CONCEPT ANALYSIS)

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NAS SYSTEM LIFE CYCLE

Figure 1-1

3.0 FINDINGS

This section documents the findings from the documentation reviews and the interviews.

3.1 DOCUMENTATION REVIEW

3.1.1 Summary

The FAA has in place today a baseline set of standards and orders which reflect the current policy and process for software life cycle management. This set of orders and standards must all work together as an integrated process and policy. Further, whenever new standards or orders are developed, they must be totally integrated into the existing set.

This set includes as a foundation the following standards and orders:

FAA-STD-005	FAA Order 1800.8
FAA-STD-018	FAA Order 1810.1
FAA-STD-021	FAA Order 1810.2
FAA-STD-024	FAA Order 1810.4
FAA-STD-025	FAA Order 4630.9
FAA-STD-026	

Along with these, a new Action Notice which selects Ada as the language of choice for the FAA has been approved.

The results of the documentation review are summarized as follows:

(1) In general, there is broad but not specific agreement on the definition of the FAA NAS acquisition life cycle within the documents reviewed. The terminology used within the standards and orders is not consistent. Generally, terms and products are defined but on occasion terms are used which are not defined.

(2) Some phases of the NAS System Life Cycle are not addressed by any of the reviewed or identified guidelines (see Appendix D). These phases include, but are not limited to, the Concept Definition and Verification phase, transitioning from Requirements Definition into Acquisition and from Acquisition into Operational Support.

(3) Certain software engineering topics are not addressed by any of the reviewed FAA standards or orders. Examples include Commercial Off-the-Shelf Software (COTS), software metrics, software management, software reuse, documentation management

prototyping, and software risk assessment procedures and methods.Metrics were specifically mentioned in the ISSS Task Force Report (DOT/FAA-17) as and area requiring attention. "...a set of metrics...must be developed, documented and used to unambiguously measure progress on a build by build basis."

(4) The NAS-SS-1000 includes a list of applicable standards and orders for all NAS F&E projects. This implies that R,E&D and the maintenance organizations are excluded from this requirement. This approach does not support a full NAS life cycle view of product development within the FAA and contributes to the compartmentalization which leads to lack of communication and inefficient development of software products for the NAS.

(5) Since the FAA has adopted DoD-STD-2167A as the basis for FAA-STD-026, all other military documents which are referenced by FAA standards and by 2167A itself may be out of date and must be reviewed to assess the impact of this situation on the guidelines in use by the FAA. Review of these military documents is outside the scope of this task.

(6) A number of the FAA Standards and Orders do not provide enough detailed and specific information to allow a straightforward and consistent implementation of the stated procedures. Specific examples are listed in Appendix B and are summarized below as lacking in the following areas:

(a) Deliverables - The standards/ orders do not completely specify the deliverables that must be generated in accordance with the procedures. For those deliverables that are identified, only minimal information is provided concerning the format or content of the items.

(b) Timeframe/Duration - The standards/orders do not provide sufficient information concerning the timeframe and duration of the activities and deliverables that are addressed in the procedures.

(c) Activity Details - The standards/orders do not provide enough detailed procedural information to properly support measurement and assurance of conformance to procedures. The procedures use activity descriptions such as "coordinate", "notify", and "advise" while providing no definitions of what these terms mean in the context of the standard/order.

(7) The standards/orders are not consistent with respect to the treatment of firmware. Some of them state that firmware is to be treated as software, but most of them do not address the issue at all.

(8) "The FAA's maintenance planning tool is the national Airspace

Integrated Logistics Support (NAILS). NAILS uses Military Standard 1388 (1A and 2A) to provide Logistic Support Analysis (LSA). Military Standard 1388 and NAILS do not presently handle software, accommodate software support data or enable software support to be analyzed." (WARREN89)

(9) Ada has been adopted by the FAA as the preferred language while allowances are made for using other languages when appropriate. Language standards which cover each language allowed should be put in place by the FAA.

3.1.2 Detailed Findings

Appendix B lists the details of the document reviews by TPI and itemizes any issues which require attention by the FAA.

3.2 INTERVIEWS

3.2.1 Summary

For this task, 31 interviews were conducted, and a survey was conducted to determine the familiarity of the interviewees with various documents. The details of the survey results are contained in Appendix H. A summary of the survey's findings is described below.

(1) Of the 81 documents presented to the interviewees, FAA Order 1810.4b FAA NAS Test and Evaluation Program received the highest level of recognition. The second highest level of recognition was DoD-STD-2167A Defense System Software Development.

(2) Of the 81 documents, one (1.2% of all documents) received a score of zero, which indicated a lack of knowledge about the existence of the document. This document was FAA Order 1370.53 Uniform Document Standards.

(3) Of the 81 documents, 9 (11.1% of all documents) received a score of one, which indicated that the document is known to exist but its usage could not be explained.

(4) Based on the above results, a total of 10 (12.3% of all documents) in the survey received either no recognition or low recognition scores.

General observations based on the interviews are itemized below.

(1) Of the three major life cycle phases (Requirements Definition, Acquisition, and Operational Support), the Requirements Definition phase is handled the poorest within the FAA. Lack of adequate requirements definition was stated as the greatest influence on the success or lack of success during all subsequent phases. Few guidelines exist in the form of standards or orders which address this phase. For the Concept Definition and Validation phase, no FAA guidelines are known to exist.

The Operational Support phase was said to be the best phase because it "cleaned up the messes" and did not allow a system to be deployed which did not meet requirements (i.e. needs) even though it met specifications. This is more evidence of a problem with the requirements definition process. An inadequate job of requirements definition leads to rejections during testing because "it wasn't what was really wanted." Having the vendor build the wrong system, even correctly, is very expensive for the FAA. These problems should be caught much earlier.

(2) The transitions from Requirements to Acquisition and from Acquisition to Operational Support were also mentioned as causes for problems. The transitions are not well defined and no formal guidelines exist to help in this process. A draft action notice has been prepared by the Software Integration Working Group (SIWG) which addresses parts of this area. Transition is also addressed to some extent in FAA Order 1800.8.

In general, the mechanism used to communicate and to obtain agreements about the process during the Acquisition to Operational Support transition is a Memorandum of Understanding. A contributing factor to the difficulties with the transitions is that different organizational groups are involved. Also the requirements tend to be readdressed at the Acquisition to Operational Support transition point even though prior agreements and sign-offs occurred during the Program Definition phase.

(3) One of the points that was mentioned repeatedly during the interviews was the lack of enough skilled and up to date software engineers within the FAA. This appears to be the case throughout all phases of the life cycle and at all career levels. A lack of well trained program managers with software background or knowledge was also cited as a problem for the FAA.

(4) Interpretation and tailoring of the standards and orders has been difficult for the FAA. Many of the standards now available are new to the FAA, especially DoD-STD-2167A, and expertise has not yet been developed within the FAA. DoD-

STD-2167A was cited over and over as having problems when used within the FAA environment. The FAA views 2167A as adequately addressing the Acquisition phase, but 2167A does not provide enough support for the Post Deployment Support activities for the FAA.

(5) The guidelines do not stand alone and do not have adequate instructions for interpretation and use. In general, tailoring guidelines are missing. As illustrated in Appendix A, most of the guidelines reference several other guidelines and while not shown, these may reference several more. The lack of tailoring guidelines was reported several times as being a problem for the FAA.

(6) The 'culture' within the FAA was mentioned during the interviews as "getting in the way of success." This may be interpreted to mean that organizational divisions and different perspectives make agreements difficult to achieve. It also seems to imply that the narrow focus of each group, whether engineering or air traffic, inhibits cooperation and accommodation.

(7) In general, the personnel do not know how to get copies of the guidelines or what guidelines exist. There may be guidelines which are applicable to their area but they are unknown. In some cases, the people rely upon their manager to give guidance with respect to standards which are applicable.

(8) Another issue which came up during the interviews was the perceived lack of emphasis on minimizing life cycle costs for projects. Each group appears to only concern itself with its own phase of the project. There are no apparent incentives to encourage a life cycle view of costs by all organizations.

(9) Some new policies or standards are currently under consideration. Examples of these include a possible set of standards which specify the minimum level of qualifications for a vendor who provides training to the FAA and guidelines for COTS within the NAS.

3.2.2 Detailed Findings

Appendix C lists the details of the interviews and provides a summary of the problems addressed and the answers received.

4.0 CONCLUSIONS AND RECOMMENDATIONS

4.1 CONCLUSIONS

The FAA has addressed the NAS software acquisition problems over the years and many guidelines exist as a result of these efforts which are valuable and which provide the needed support to the FAA Program Managers and Software Managers. The FAA Order 1800.8f is especially worth noting for its completeness and detailed guidelines for Configuration Management. Basically, there are many noteworthy guidelines which need updating in order to become more useful in today's environment.

A NAS software acquisition process is in place within the FAA and this task has attempted to clarify that process and to evaluate whether or not the process is adequate and effective.

Many of the pieces for an overall NAS software acquisition policy and guidelines exist and what is needed is the thread to pull them all together into a cohesive strategic plan. As a result of the document reviews and the interviews the following conclusions were developed. They are not listed with regard to any priority.

(1) The Requirements Definition phase of the life cycle is inadequately performed within the FAA. Clearly a serious problem, not unique to the FAA, the lack of a sound approach to requirements determination/specification is a source of life cycle cost expenses to the FAA due to the large amount of rework required to develop a system acceptable to the customer (AT). This phase contributes directly to the success or failure of NAS programs and must be given priority attention in terms of resources, including equipment, personnel and budgets. There is no evidence that incentives exist which would encourage AT to define needs early and adequately.

(2) Requirements are a moving target within the air traffic domain and this is an accepted way of life within the FAA to almost everyone. However, it is not accepted by the Program Managers who are attempting to finish a program on schedule and within budget against the SOW and Requirement Specifications initially bid on by the contractors.

(3) There is no overall software engineering policy statement within the FAA which provides the system level guidance for all other software engineering activities within the FAA. Such a policy statement should address critical areas such as organizational commitments and accountability and containment of cost along with specific software technology and management guidelines.

(4) A consistent system-level definition of the NAS System Life Cycle is missing around which the FAA can structure its policies, procedures, standards and orders.

(5) A glossary of terms specific to the FAA environment, life cycle and business methods is not available.

(6) Centralized guidelines missing within the FAA for several software engineering topics. The matrix in Appendix D illustrates which software topics are not addressed by guidelines. Examples include COTS, software risk analysis and risk analysis and risk management, software metrics, and software management. COTS guidelines have become especially crucial since current NAS projects, such as AAS, have an important COTS content.

(7) A centralized guideline for evaluation of vendor standards for software design and code is not currently available within the FAA. The FAA requires guidelines as to what is a minimum acceptable standard when evaluating a vendor's proposed software design and code standards. In general, guidelines are not available which address software technology and its management in this rapidly changing environment.

(8) Some transitions between phases are addressed in FAA Order 1800.8. However, the transition from one phase to another in the life cycle was mentioned as a problem area during the interviews. It is clearly recognized by the FAA as such and steps are being taken to address it. There is an Action Notice which addresses the hand-off process from acquisition to operational support which is a start in addressing some of the issues.

(9) The use of DoD-STD-2167 (and now FAA-STD-026/DoD-STD-2167A) has been difficult and the need for expertise in these standards has been raised several times during the interviews. There is general lack of understanding within the FAA concerning DoD-STD-2167A, especially in the area of tailoring. Additionally, it is an ineffective mechanism for maintenance/change specification since: (a) the customer (AT) does not understand it; (b) its organization hinders a "clean" presentation of the proposed changes; (c) it does not specify MMIs well; and (d) it lacks a Computer Program Functional Specification (CPFS).

(10) There is an insufficient number of strong software engineering experts within the FAA who could provide the leadership required to manage this complex technology for the FAA. Furthermore, there is a lack of systems engineers who understand both software and the air traffic control environment. There is also a lack of Quality Assurance personnel trained in software engineering.

(11) Other than an informal network of contacts, there is no mechanism for sharing lessons learned and for knowing what is available in the software engineering area within the FAA. Software personnel do not know where or how to get copies of the existing guidelines.

(12) There is a lack of incentives which encourage and support the notion that life cycle cost containment is the responsibility of each organization in the FAA.

4.2 RECOMMENDATIONS

(1) The FAA should implement new approaches to defining requirements. The distinction between needs, requirements, and specifications should be addressed and understood. Needs are what AT has, these needs are expressed through requirements definitions and requirements are documented in specifications to be used by the builders of the products. Part of the difficulties experienced by the FAA with requirements determination may be that these distinctions are not made and understood by either the user (AT) or the builders (engineering). Rather than expecting AT to define their requirements, AT should be asked to define and discuss their needs (i.e. what problem are they trying to solve) and then the system analysts (i.e. engineers) should define the requirements that will satisfy the needs and then document these requirements in a specification.

At the lower levels of requirements determination, such as the Man-Machine Interfaces, a distinction between functional requirements and build-to specifications is not made within the FAA. That is, the FAA tends to think of build-to specifications as functional requirements. Thus, while prototyping is used to define requirements according to the FAA, it often results in build-to specifications rather than functional specifications.

This distinction is important when a program is defined since the contractor has more flexibility with design and implementation when given functional specifications; this may then require more stringent management and technical controls in the form of standards being imposed in the contract. In other words, the tailoring requirements for a program are quite different when the program has functional rather than build-to specifications. Build-to specifications may be more desirable in the FAA environment for satisfying some operational needs.

TPI recommends that the FAA analyze all aspects of the way requirements are currently defined including who defines them, who is responsible and accountable for definition of

requirements, and what is the process used. Although there are guidelines in place for writing System Requirement Specifications, they are incomplete and ineffective as demonstrated by uncontrolled changing requirements and the disagreements about whether requirements have been met during the transition from acquisition to operational support.

(2) Changing requirements cannot be prevented within the FAA operational domain. As with any other type of change, there should be a conscious, well- reasoned decision to pursue changes during the current acquisition, or alternatively to defer them to the future. "Management guidance should encourage and support this deferral and accept the consequences of doing so." [MIL-DOC-1]

Within the FAA, changed requirements are often not identified until the transition from acquisition to operational support. To alleviate this problem of late identification of changed requirements, new approaches to management during acquisition need to be tried which will seriously involve the end users at all steps of the acquisition. While the end users are now expected to participate in reviews and to review all documentation during the acquisition phase, this participation is apparently not effective or not occurring and needs to be studied as to why it is failing. Guidelines for managing changing requirements may prove useful. A review process such as that used for Deployment Readiness Review is suggested.

(3) There is a need for an overall FAA policy statement with respect to NAS Software and the NAS System Life Cycle. This policy statement should be the guide for decision making and prudent management of software within the FAA. Currently there are several individual efforts which concern software engineering taking place in the FAA and there is no coordination between these efforts to prevent duplication or conflict. A policy to guide these individual efforts and to provide a vehicle for communication and coordination is required.

The policy statement is not the panacea for problems within the FAA but can set the tone and system level guidance for the software standards and orders within the FAA. Furthermore, a policy statement will not make up for poor software management or for ill-equipped and poorly trained managers.

The types of items which should be considered by the policy statement include:

(a) A "software first" approach to NAS System Acquisitions. That is, address user needs and functional requirements and the software approach to satisfying them first before specifying the hardware.

(b) The role of state-of-the-art software technology and software production techniques

(c) Grandfathering existing programs once under contract.

(d) Introduce the concept of "reasonable judgement" in management of software.

(e) The need to tailor standards for each program.

(f) Organizational and management commitments to software engineering.

(g) Cost containment.

(4) Establish temporary working groups which involve members from across the FAA organization. These working groups would have specific mission charters which address very specific and narrowly focused software engineering needs within the FAA. The objectives of the working group should be well focused on specific products to be developed by the working group. Products should include:

(a) a NAS software policy statement,

(b) development of a consistent definition of the NAS System Life Cycle,

(c) development of an FAA Glossary of Terms,

(d) new or revised standards or orders,

(e) Guidelines for evaluation of vendor standards for software design and production.

(f) Guidelines for conduct of program reviews.

Once the product is delivered and has gone through an acceptance process, the working group should be disbanded or assigned another task.

(5) There is a scarcity of systems engineers with software credentials, a scarcity of software engineers with system perspectives, and few of either with air traffic understanding. Thus TPI recommends the establishment of a system level software engineering group with expertise available to work with the FAA Program Managers and Software Managers. This group of software/systems/air traffic advisors can observe many programs over a relatively short time span, enjoy a rapid learning curve, and apply lessons learned immediately.

This group should be available as in-house consultants to any organization within the FAA which requires assistance with systems and software engineering technology. This group should be staffed by people with strong qualifications in systems, software, and air traffic control. Over time, these people would become well versed in each others disciplines and provide the much needed expertise across all of these disciplines.

(6) Establish better communications vehicles for sharing "lessons learned" and for continuing education of the software management in the FAA. Some possibilities include an on-line conferencing system, an on-line database of all standards, orders, etc., an on-line database of software topics pointing to relevant guidelines, quarterly presentations of updated guidelines and quarterly "lessons learned" brown bag sessions.

(7) Provide a software managers handbook. This handbook should include the NAS Software Acquisition policy statement. This handbook should cover the what, where, when, and who of software management within the FAA:

(a) What guidelines the managers need,

(b) Where to get the guidelines,

(c) When to apply the guidelines,

(d) Who to see for assistance with the guidelines.

The guidelines themselves should provide the 'how' part of the software managers handbook.

(8) Prepare a technology transfer plan for software engineering within the FAA. Address the management of technology change and the mechanisms for keeping personnel current, as well as related topics.

(9) One or two pilot projects are recommended by TPI as a way to apply some of the new approaches to software engineering within the FAA. That is, bring together the expert group (system, software, air traffic) to tailor the guidelines for a project. Try other approaches to requirement definition and software management. Other suggestions should be discussed and applied as found appropriate by the FAA.

5.0 PROPOSED ACTION PLAN

The action plan proposed by TPI is presented in this section. The action plan is the result of all document reviews, personnel interviews, and feedback received on the earlier TPI reports. The plan is divided into near, mid, and long-term tasks. The near-term tasks are to be accomplished within the next one to three months. The mid-term tasks are to be accomplished within the next three to twelve months, and the long-term tasks are to be completed beyond twelve months from now. The phased-in approach of the action plan supports the incremental attainment of the goals identified in Section 1.2.

5.1 NEAR-TERM TASKS

In general, the near-term tasks are intended to fill in gaps which are immediate in nature and which further define the software engineering process within the NAS System Life Cycle. Attainment of these objectives then enables the mid-term tasks to commence.

(1) Give briefings on this work (Task11) to all of the FAA organizations who have participated.

(2) Develop a "strawman" FAA Software Policy statement and transition this into an official policy statement.

(3) Develop quick reference charts for use by the FAA software community showing the life cycle and applicable standards and orders.

(4) Develop a database of NAS System Life Cycle vs Guidelines Matrix.

(5) Develop a strategic Software Process Improvement Plan for the FAA including plans for:

   a. Identifying and resolving conflicts among existing standards,

   b. Creating a framework for practical use and tailoring of 2167A,

   c. Creating a software engineering training curriculum,

   d. Transitioning development among phases (e.g., entry and exit criteria, traceability relationships, consistency/completeness criteria),

   e. Expanding Action Notice 1370.9,

f. Providing guidelines for dealing with COTS software,

g. Assessing current FAA software engineering skills,

h. Promoting effective requirements development,

i. Addressing Technology Transfer issues.

5.2 MID-TERM TASKS

The mid-term tasks continue the software engineering process definition in more detail and implement some of the new processes.

(1) Implement the FAA Software Process Improvement Plan. Based upon work completed during Task 11, implementation is likely to include the tasks discussed below.

(2) Expand the Action Notice 1370.9 to address all of the issues of concern with respect to Ada:

(a) What systems should be excluded from the Ada requirements, if any,

(b) What Ada coding standards are needed,

(c) What Ada metrics are appropriate,

(d) Address any issues with using other languages with Ada,

(e) Address Ada and the R,E&D activities,

(f) Address the Ada 9X impact.

(3) Develop a Software Managers/Engineers Handbook; develop an outline with the initial emphasis on what guidelines are needed, where to get the guidelines, when to apply the guidelines, and who to see for assistance with the guidelines.

(4) Update the existing guidelines to reflect the current FAA organization and current technical terminology. Incorporate fixes for the problems indicated in Appendix C of this report.

(5) Develop a NAS System Life Cycle (expanded version) with the addition of roles information; indicate which FAA organizations have responsibilities at each phase of the life cycle and for which products and activities they are responsible.

(6) Develop and offer a software engineering training curriculum for management and technical software engineering personnel in the FAA, including such topics as:

(a) Use of Software Managers/Engineers Handbook,

(b) Software Engineering Environments,

(c) Software reuse,

(d) Software risk management,

(e) Software metrics,

(f) Software Project Management,

(g) Software Design Methods,

(h) Style for the Professional Ada Programmer,

(i) Conducting Effective program reviews,

(j) Conducting an assessment of vendor software development processes,

(k) Tailoring of guidelines, especially 2167A,

(l) Effective Software Quality Assurance.

(7) Develop missing guidelines for:

(a) Conducting PDRs and CDRs,

(b) Evaluation of vendors standards for software design and code,

(c) Risk Management,

(d) Tailoring of the guidelines, especially 2167A.

(8) Initiate investigation of what the DoD tailoring activities are with respect to DoD-STD-2167A and DoD-HNBK-287. DoD has an automated tool for tailoring of 2167A, and the FAA should investigate the feasibility of bring that tool into the FAA environment. The FAA was a test site for this tool, but it does not appear to be in use by the FAA.

(9) Develop a new approach for managing changing requirements; this would first involve understanding the current approach in terms of who defines requirements, who is accountable for requirements definition and who controls budgets which are affected by changes to requirements.

(10) Investigate the current practice within the FAA with respect to the use of software metrics for both management and technical control and tracking of software development for NAS

systems. Select specific projects now in progress as samples to be used in this assessment. Compare these projects against a set of software metrics which are considered valid by current software engineering practitioners.

5.3 LONG-TERM TASKS

The long-term tasks fully implement and provide evaluation of the new guidelines and the new software engineering processes.

(1) Establish one or two pilot projects for application of the new software engineering approaches and guidelines and assess impact on such projects.

(2) Develop an on-line database of NAS System Life Cycle items versus the applicable guidelines for these items. This is to automate the matrix in Appendix D and enable rapid retrieval of this information by the software community in order to assist them with their technical or managerial tasks.

(3) Develop an FAA specific glossary of terms to supplement the IEEE STD 729 which is currently in use by the FAA.

(4) Define and put into practice a procedure for conducting independent process assessments of bidders and contractors as part of the FAA risk assessment approach. Establish a minimum set of requirements with respect to a Software Development Environment for various types of contracts.

(5) Develop a NAS project database which provides information such as what languages were used, what standards were applies, what documentation was required, what tailoring was applied and other pertinent software data. This database could provide guidelines to new projects.

APPENDIX A

DOCUMENT LIST

ITEM ID	ITEM TITLE	FAA Orders	FAA-STDs	FAA Forms	DOD-STDs	MIL-STDs	Documents
AC 00-41	FAA Quality Control System Certification Program (for guidance and information)						
Action Notice (Draft)	Procured Software Hand-Off Procedures	1800.8	021a		2167A 1521B		
Action Notice 1370.9	NAS Software Procedures	1800.8	026			1815A	
DOD-STD-2167A	Defense System Software Development				480 2168	12 481A 483 490A 499A 1521B	DOD FAR Sup.27.410-6 DOD 5000.19-L DOD-HDBK-287
FAA Order 1100.121a	Management of Air Traffic Control Automation	1100.5 1100.102c 1320.33 1800.8f 1800.25 1800.27 1800.29					
FAA Order 1100.124	AT/AF Responsibilities at NAS Computer Equipped ARTCCs	1100.121a 1370.18 1800.8f					
FAA Order 1100.134a	Maintenance of NAS Automation Subsystem	1100.121a 1100.127b 1800.8f 6032.1a					SPO-MD-0 01
FAA Order 1100.145b	Program Technical Report (PTR) Procedures						
FAA Order 1320.48b	Engineering Field Support Sector Maintenance Program Procedures	1000.1 1100.134a 1320.1a 1320.33 1320.35a 1380.40a 1800.8f 3450.7c 6000.20b 6032.1a					

ITEM ID	ITEM TITLE	FAA Orders	FAA-STDs	FAA Forms	DOD-STDs	MIL-STDs	Documents
FAA Order 1370.52b	Information Resources Management - Policies and Procedures	1110.106a 1350.22 1370.6a 1370.9 1370.10 1370.20c 1370.32b 1370.50f 1370.52a 1370.53 1370.54a 1770.27a 1770.33 1810.1d 1830.2 2510.12b 4400.18a					DOT Order 1375.1
FAA Order 1370.53	Uniform Document Standards	1600.54					
FAA Order 1600.54B	FAA Automated Information Systems Security Handbook	1000.32 1350.22a 1370.32b 1370.43 1370.47a 1370.48 1370.52b 1370.53 1600.1c 1600.2b 1600.6b 1600.8b 1600.15d 1600.39a 1600.40 1600.46 1600.49b 1600.56 1650.7b 3900.19b 6930.1a		1600-56			
FAA Order 1800.	National Airspace System (NAS) Deployment Readiness Review (DRR) Program	1810.4b					
FAA Order 1800.25	Configuration Control Support Facility						
FAA Order 1800.58	National Airspace Integrated Logistics Support Policy					1388.2A	

ITEM ID	ITEM TITLE	FAA Orders	FAA-STDs	FAA Forms	DOD-STDs	MIL-STDs	Documents
FAA Order 1800.8f	National Airspace System Configuration Management	1100.134a 1100.144 1230.10 1320.48b 1800.57 1800.58 1810.1d WA 4400.1 4405.5 4405.15 4420.4 6000.20b 6030.29 6032.1a 6120.1	002c 005d 021a 025a 026	1800-2 1800-15 1800-17 1800-49 6030-3 6100-1		1521B	FAA-D-2494 FPMR Temp. Reg. D-73 NAS-MD-001 NAS-SR-1000 NAS-SS-1000 NAS-DD-1000
FAA Order 1810.1d	Major Systems Acquisition Management	1200.81 1810.2 1810.3					DOT Order 4200.14b OMB Circular A-109
FAA Order 1810.2	Independent Operational Test and Evaluation for Major Systems Acquisition						
FAA Order 1810.3	Cost Estimation Policy and Procedures	1810.1d					DOT Order 4200.14b FAA APO 81-3 FAA APO 82-1 OMB Circular A-109
FAA Order 1810.4b	FAA NAS Test and Evaluation Program		024a				
FAA Order 3000.6b	Training						
FAA Order 3020.1a	Use of Computer-Based Instruction	1600.54 3000.6b 3000.16a 3120.4					
FAA Order 4405.15	Reprocurement Data Acquisition Policy						FAA-G-1210
FAA Order 4453.2a	FAA Quality Control System Certification Program		013a 016a				AC 00-41 MIL-I-45208A
FAA Order 4630.8	Quality Assurance Policy						
FAA Order 4630.9	FAA Computer Software Quality Program Requirements		013a 016a 018a				
FAA Order 6000.10	Airway Facilities Service Maintenance Program (inactive)						

ITEM ID	ITEM TITLE	FAA Orders	FAA-STDs	FAA Forms	DOD-STDs	MIL-STDs	Documents
FAA Order 6000.30a	Policy for Maintenance of the NAS						
FAA Order 7032.2b	Air Traffic Operational Requirements						
FAA-STD-002	Engineering Drawings	1000.15 7340.1	005d 023				
FAA-STD-005d	Preparation of Specification Documents		002 021a 030			480 490A	
FAA-STD-013a	Quality Control Program Requirements						MIL-C-45662A MIL-I-45208A
FAA-STD-016a	Quality Control System Requirements		018a 021a 024a			45662	AC 00-41
FAA-STD-018a	Computer Software Quality Program Requirements		013a 016a		2167A	1521B	IEEE STD 729
FAA-STD-021a	Configuration Management (Contractor Requirements)	1320.33 1800.8f	002 005d 016a 018a 025a	DD 2423 DD 1692	100 480 2167A	482 499A 1521B	FAA-G-2100 Handbook H4-1
FAA-STD-024a	Preparation of Test and Evaluation Documentation						
FAA-STD-025b	Preparation of Interface Control Documentation and Interface Requirements Documentation		002 005d 023		100 2167A		IEEE 315 ISO 7498
FAA-STD-026	NAS Software Development		005d 018a 021a		2167A	499A	AFSC 800-43
FAA-STD-028	Contract Training Programs		021a 010			1381	FAA-G-2100/c FAA-D-2494/b FAA-D-2706 MIL-T-4782C FIPS Pub. 11-1 GPO Style Manual DOD-5220.22M AFP-50-58 CDC PLATO User's Guide

ITEM ID	ITEM TITLE	FAA Orders	FAA-STDs	FAA Forms	DOD-STDs	MIL-STDs	Documents
FAA-STD-030	Preparation of Procurement Request Packages	1810.1d 4630.9 4400.42 4453.2a	005d 013a 016a 018a 021a 026 031				DOD 5000.19-L DOT Order F 4200.1 DOT Order F 4200.2 DOT Order 4200.14b DOT Order 4400.6 DOT Order 5010.12 FAA-D-2494 FAA-G-1210 FAA-G-1375
FAA-STD-031	Preparation of Statement of Work	1600.54 1810.1d 6000.10 6000.26 6000.30a 6050.19	002 005d 013a 016a 018a 021a 023 024a 025a 028 030		100 963 2167A	100 470 471 781 785 881 1388-1 1388-2A 1472C 1521B 1561	DOD-D-1000 FAA-D-2494 MIL-HDBK-245 NAILS Plan NTIA RP-FRFM
FAA-STD-034	Instructions for the Preparation of Logistics Support Analysis (LSA) Data	3000.6b	028 1210			12 100 882	Controlled Sub. Act DOD 4100.38-M DOD 4100.39-M DOD 4130.2-M Hazardous Nat'l Reg. Maint. Manual 6080.6 MIL-D-1000
FAA-STD-035	Commercial Equipment, Market Research for Preparation of Project Implementation Plan						
FAA-STD-036	Preparation of Project Implementation Plans	1320.1a 6020.2					

ITEM ID	ITEM TITLE	FAA Orders	FAA-STDs	FAA Forms	DOD-STDs	MIL-STDs	Documents
NAS-SS-1000	NAS System Specification	1010.51 1010.55 1600.2 1600.8 1600.40 1600.54 1800.8 1810.1 4630.8 6000.26 6000.30 6365.1 6740 7110.65 9840.1	002 005 013 016 018 019 020 021 022 024 025 028 032 033 034 035		100 2167	461 470 785 882 1388 1472 1561 2073 2165	FAA-G-2100 FAA-D-2494 COMTINM16562.4 DOD-D-1000 MIL-H-46855 NTIA Manual CFR Title 29 FAA Handbook 8260.3_ AC-00-26 AC-00-31 A.N. 1810.1 NAS-DD-1000 NAS-MD-320 NAS Plan NAS-SR-1000 NAILS Master Plan NAS Training Plan Traceability Matrix Verification Plan Verification Handbook

APPENDIX B

DOCUMENTATION REVIEW

DETAILED FINDINGS

STANDARD/ORDER	DOCUMENT TITLE	SECTION	PAGE	COMMENTS
Action Notice	Procured Software Hand-Off Procedures	General Comment	N/A	The procedures outlined in this action notice directly effect the contents of a contract between the FAA and a vendor. It implies requirements which may not have been in the original SOW or Functional Specification and yet this action notice is to be applied to all AAP-300 NAS projects if hand-off has not yet occurred. This exposes the FAA to contract changes and increased costs for current projects.
		General Comment	N/A	This action notice was clearly written by ATR. The tone of the action notice puts responsibility for getting agreements on APP and gives authority for saying 'no' at any time to ATR. It does not sound like this is an agreement between equals with both having equal responsibility and authority for its success or failure.
		5.1	3	ADL is no longer an FAA organization code.
		5.1	3	The view that a Type 3 Project "will not be integrated into an existing operational system," ignores the need to consider interfaces with existing systems.
		6.a	3	Does the First Article acceptance milestone refer to that event on AAP's schedule or on ATR's schedule? (reference the disclaimer in 5.e, last sentence.)
		6.a	3	Who is the authority to assure the MOU agreement date is met? Who arbitrates disagreements?
		6.a	3	Can the MOU which is initially agreed to, be modified? If so, by what process and authority?
		6.d	4	Who conducts the referenced configuration audits and how many are there? Who conducts the referenced design review and where are the criteria for success defined?
		6f(4)	4	Where is the 'sufficient time' defined and who defines it?
		6f(6)	5	'Functional equivalence' leaves a lot of room for disagreement; who gets to make the call as to whether or not this is met?
		6g(2)	5	Why does ATR have their own format for documentation? It would seem that the FAA should have a standard format.
		6g(4)	5	The need to support 'existing ATR support equipment' may prohibit advances in technology within the FAA support environment.
		App. 1, third para.	9	Perhaps the budget for the 'delta development effort' should come from ATR as part of their responsibility. This would be an incentive for ATR to define their needs early and to encourage full ATR participation during acquisition.

STANDARD/ORDER	DOCUMENT TITLE	SECTION	PAGE	COMMENTS
Action Notice 1370.9	NAS Software Procedures	General Comment	N/A	Be specific as to what validation authority the compiler must be validated by. Methodology is being imposed when a PDL is required for design documentation; does the FAA mean to impose a software methodology? The notice specifically addresses acquisition and post-deployment support; it should also address R,E&D use of Ada. "More than one-third" is not a good measure; 1/3 of 20,000 LOC may not be cost effective for switching to Ada, 1/3 of 200,000 LOC may be cost effective. 1/3 of assembly language code may still need to be in assembly language code. The action notice does not address the following items: - Guidelines as to what types of systems should be excluded - Need for ADA coding standards, especially to address performance issues - Need for Ada metrics - Potential impact of Ada 9x
DOD-STD-2167A	Defense System Software Development (and related DIDs)	2.1.1	3/4	Should probably reference DoD-STD-2168 (Software Quality Assurance Program Requirements) regarding S/W SQA interface.
		4.1.4	9	Where are S/W Risk Management requirements documented during software development cycle?
		4.1.5	9	Where are S/W Security requirements documented during software development cycle?
		4.1.8	11	Does not provide much information concerning the structure and content of the proposed software library(ies). Should either provide additional or reference Configuration Management standard.
		4.2.1	11	Are guidelines available for tailoring of software development methods to support formal audits and reviews required by contract (MIL-STD-1521A)?
		4.2.3	11	Where are S/W Safety requirements documented during software development cycle?
		4.2.6	14	Need to include requirement for full traceability from: - Specific software design documents to source code - Software requirements and interface specifications to software test plans - Software design documents to software test descriptions (procedures)

STANDARD/ORDER	DOCUMENT TITLE	SECTION	PAGE	COMMENTS
DOD-STD-2167A (continued)		5.1.4 & 5.1.5	19	States that SDP should be placed under CM control, but does not address preparation of SDP in Section 5.1.2 (Software Engineering).
		5.3	23	Should the Computer Program Functional Specification (CPFS) be required during the Preliminary Design phase?
		5.5.5.1	27	States that updated SDDs should be placed under CM control, but does not address updating of SDDs in Section 5.5.2 (Software Engineering).
		5.7.4 & 5.7.5	31	No product evaluation criteria were specified for the following products: - Software Design Document (SDD) - Software Test Description (STD) - Interface Design Document (IDD) - Version Description Document (VDD) - Software Development Files (SDF)
		5.7.5.2	31	Wording should be changed so that Development Configuration does not cease to exist after FCA and PCA (consistent with FAA-STD-026. Development Configuration should continue to exist to support ongoing system maintenance and enhancements.
		5.8.2	33/34	When are the following documents prepared/submitted to FAA? - Operation and Support Document (OSD) - Computer Resources Integrated Support Document (CRISD) - Computer Software Operator's Manual (CSOM) - Software User's Manual (SUM) - Software Programmers's Manual (SPM) - Firmware Support Manual (FSM)
FAA Order 1100.121A	Management Of Air Traffic Control Automation Systems	General Comment	N/A	Order references a number of other orders by number only - no titles are included.
		General Comment	N/A	Where is information concerning format and content of deliverables addressed in order?
FAA Order 1100.124	AT/AF Responsibilities at NAS Computer-Equipped ARTCCs	General Comment	N/A	Order could use more detail concerning organizational responsibilities.
FAA Order 1100.145b	Program Technical Report (PTR)	General Comment	N/A	Order does not provide enough specific information regarding implementation of the procedures.
		General Comment	N/A	Order would provide a better means to ensure conformance to its procedures, and to ensure a straightforward and consistent implementation, if more implementation details were provided.
		General Comment	N/A	Order might be easier to follow if PTR form was included as part of procedures.

STANDARD/ORDER	DOCUMENT TITLE	SECTION	PAGE	COMMENTS
FAA Order 1100.145b (continued)		General Comment	N/A	Do PTR procedures address firmware as well as software?
FAA Order 1320.48B	Engineering Field Support Sector Maintenance Program Procedures - National Airway Engineering Field Support Sector, APM-150 , and National Automation Engineering Field Support Sector, APM-160.	12.C	9	Order references "current internally imposed standards." What are these standards and where can they be found?
		General Comment	N/A	Order does not provide enough specific information regarding implementation of the procedures.
		General Comment	N/A	Order would provide a better means to ensure a straightforward and consistent implementation if more implementation details were provided.
FAA Order 1800.58	National Airspace Integrated Logistics Policy	General Comment	N/A	Software support requirements are not clearly reflected. Update to ensure that software support requirements are included.
FAA Order 1800.8?	National Airspace System (NAS) Configuration Management standard	General Comment	N/A	Order provides little information concerning the interface between the software configuration management and software quality organizations.
		General Comment	N/A	Order does not address a means to ensure the proper implementation of a software configuration management program by verifying that the proposed software configuration management products meet and are traceable to specified software configuration management requirements.
		General Comment	N/A	Order is oriented towards large software projects; to use it on a small software development project would require some tailoring required to eliminate unnecessary activities and documentation requirements.
		General Comment	N/A	Based on the documentation requirements and audits/reviews contained in it, the Order tends to best support a traditional waterfall approach.
		General Comment	N/A	Order is not very concise. It is not a stand-alone document; it contains a large number of references to other external documents. It is not easily understandable; the large number of Appendices tends to cause a lot of referencing and makes for a disjointed document. Possibly, the information in the Appendices could be integrated into the body of the document.

STANDARD/ORDER	DOCUMENT TITLE	SECTION	PAGE	COMMENTS
FAA Order 1800.1	National Airspace System (NAS) Deployment Readiness Review (DRR) Program	Append. 2	3	FAA-STD-026 uses nomenclature for interface control documentation that is different than that used in FAA Order 1800.?? (IRS and IDD vs. IRD and ICD).
		Append. 2	5	What is a PTD?
		Append. 2	15.a	Order references FAA Order 1810.4A ("FAA NAS Test and Evaluation Program") which has been superseded by FAA Order 1810.4B.
		Append. 2	16.q	Order describes test phases that are different than those listed in FAA Order 1810.4B ("FAA NAS Test and Evaluation Program").
FAA Order 1810.1D	Major Systems Acquisition	General Comment	N/A	Are Research and Development (R&D) projects also addressed by this order?
FAA Order 1810.2	Independent Operational Test and Evaluation for Major Systems Acquisition	6	4	Order references Department of Transportation orders. What are these orders?
		7	4	Order requires preparation of a Test and Evaluation Plan. However, no information is provided concerning the format and content of the plan.
		General Comment	N/A	Order would provide a better means to ensure a straightforward and consistent implementation if more implementation details were provided.
FAA Order 4630.8	Quality Assurance Policy	Overall Comment	N/A	Should the order reference FAA-STD-013a, FAA-STD-016a, and FAA-STD-018?
FAA Order 4630.9	Computer Software Quality Program Requirements			None.
FAA Order 7032.2B	Air Traffic Operational Requirements	8.b.(8)	all	Order refers to notification of other Air Traffic organizations. What are these organizations?
		8.c	all	Order requires maintenance and update of Air Traffic System Plan (ATSP). No information is provided concerning format and content of this plan.
		General Comment	N/A	Order would provide a better means to ensure conformance to its procedures, and ensure a straightforward and consistent implementation if more implementation details were provided.
FAA-STD-005d	Preparation Of Specification Documents	General Comment	N/A	DIDs referred to in MIL-STD-490A are not the same as DIDs referred to in DoD-STD-2167A. DIDs referred to in 2167A have an "A" designation (EX: DI-MCCR-80026A rather than DI-MCCR-80026) and reflect a new/revised version of the DIDs.

STANDARD/ORDER	DOCUMENT TITLE	SECTION	PAGE	COMMENTS
FAA-STD-013a	Quality Control Program Requirements	2.2.1	2	Requires preparation of necessary list of tests, acceptance test procedures, and test data forms. These items are not described or referenced.
		General Comment	N/A	Standard does not provide enough specific information concerning implementation of the QC program.
		General Comment	N/A	No guidance is provided regarding a means to ensure conformance to the standard.
		General Comment	N/A	Additional implementation specifics would increase the effectiveness with which the standard can be implemented.
FAA-STD-016a	Quality Control System Requirements	General Comment	N/A	Standard does not provide guidance regarding a means to ensure conformance to the standard.
		General Comment	N/A	Standard seems to be oriented towards large projects. Guidelines should be provided to allow tailoring for smaller projects.
FAA-STD-018	Computer Software Quality Program Requirements	3.1.6	3	FAA-STD-018 should describe means within the software quality organization to enforce established software development standards and procedures. FAA-STD-018 should reference an established Software Standards and Procedures document which describes the software standards and procedures to be enforced by the software quality organization.
		General Comment	N/A	CSQPP should address methods to be used in maintaining integrity of SQA program and verifying proper implementation of the software quality program.
		General Comment	N/A	CSQPP should address methods to be used in monitoring development/quality of following types of software: - Non-deliverable software - Reusable software - Software repositories - Government Furnished Software (GFS)
FAA-STD-021a	Configuration Management (Contractor Requirements)	4.3.9.2	10	FAA-STD-021a references documents from FAA-STD-005d which are not referenced in FAA-STD-026: - Software Top Level Design Document (STLDD) - Software Detailed Design Document (SDDD) - Data Base Design Document (DBDD)
		General Comment	N/A	FAA-STD-021a does not reference the following software documents which are referenced in FAA-STD-026: - System/Segment Specification (SSS) - System/Segment Design Document (SSDD) - Software Design Document (SDD)

STANDARD/ORDER	DOCUMENT TITLE	SECTION	PAGE	COMMENTS
FAA-STD-024a	Preparation Of Test and Evaluation Documentation	General Comment	N/A	FAA-STD-024a specifies test phases which are different than those specified in FAA Order 1810.4b.
		General Comment	N/A	FAA-STD-024a has test documentation requirements and uses test terminology which is different from those used in FAA Order 1810.4b and FAA-STD-026.
FAA-STD-025b	Preparation of Interface Documentation	General Comment	N/A	Standard does not address the mapping of the interface definition and development activities into the established phases of the software development life cycle.
		General Comment	N/A	Standard requires different interface control documentation than FAA-STD-026. FAA-STD-025b Interface Requirements Document (IRD) and Interface Design Document (IDD) refer to Open Systems Interconnect (OSI) while FAA-STD-026 Interface Design Document (IDD) and Interface Requirements Specification (IRS) do not.
		General Comment	N/A	FAA-STD-025b Interface Requirements Document (IRD) and Interface Design Document (IDD) state Quality Assurance Provisions while FAA-STD-026 Interface Design Document (IDD) and Interface Requirements Specification (IRS) do not.
FAA-STD-026	National Airspace System (NAS) Software Development	2.1.1	3	Should probably reference FAA-STD-018 (Computer Software Quality Program Requirements) regarding S/W - SQA interface.
		3.25	7	Reusable software should be stated as reusable software products, to include design, code, and documentation.
		5.1	10	Change wording so that Development Configuration does not cease to exist after FCA and PCA. Development Configuration should continue to exist to support ongoing system maintenance and enhancements.
		N/A	N/A	Attachment - NAS Configuration Control Decision (CCD): CCD approves change to FAA-STD-026 to include requirement for Computer Program Functional Specification (CPFS). During what phase of development will this new product be due?

APPENDIX C

INTERVIEWS - DETAILED FINDINGS

C.1 INTRODUCTION

This section presents the results of the interview processes. There have been 31 separate interviews for this task. This section presents the data gathered during the interview process along with analysis of that information. Because of the organization of this section the same issues appear in more than one section. In many sections, a summary of the issues identified during the interviews are presented along with the total number of subjects raising each issue.

C.2 PROFILES OF SUBJECTS

The subjects interviewed during this study represented all aspects of the FAA's development cycle. The subjects had between one and 20 years of experience with the FAA and were located at both FAA Headquarters and the Technical Center in Atlantic City.

The following personnel were interviewed:

Chuck Bolling	AAT-14
Ralph Caprio	ACN-310
Jerry Champion	APS-410
Ken Clark	APS-500
James Clinton	ATR-250
Steve Coulombe	ACN-130
Loni Czekalski	AMC-300
Vern Edwards	ADS-120
Dennis Emerik	ASM-160
Robert Erikson	ACN-210
Don Espinosa	AHT-400
Mary Ann Farrell	LOGICON
John Hamilton	ASA-130
Joan Hannan	AAP-120
John Horrocks	AAP-320
Willie Hunter	ASM-140
Harry Kane	ASA-210
Rick Lay	APS-300
Garry Long	AHT-500
Jim Minsterl	ASA-6
Jim Monnie	AAP-400
Harriet Neuman	AAP-220
Jacques Press	ACN-110
Bill Riehl	ASM-160
Steve Smith	ACS-320
John Timmerman	ATR-210
Gonzalo Tornell	ALG-410
Robert Ulanch	ACD-340
Jim Warner	AAF-4
John Wiley	ACD-350
Alice Wong	AOR-110

C.3 POLICIES, STANDARDS, AND ORDERS

C.3.1 SUMMARY OF SURVEY ATTITUDES TOWARD EXISTING STANDARDS

In this section the results of the interviews regarding existing standards are documented. Where there were a small number of opinions concerning a standard, it was felt that this implied that the standard does not pose a major problem. The interviewees were quite emphatic when discussing a standard that caused significant problems.

C.3.1.1 Positive Opinions

The following standards were mentioned in a positive sense by the subjects. The number of subjects that mentioned the standard in this sense is included.

FAA-STD-016a (1)
FAA-STD-018a (2)
FAA-STD-028 - good, but hard to understand (1)
DoD-STD-2167A - for development (1)
DoD-STD-2167A - for maintenance/replacement of systems (1)
FAA Order 1100 series (1)
FAA Order 6100 series (1)

C.3.1.2 Negative Opinions

The following standards were mentioned in a negative sense by the subjects. The number of subjects that mentioned the standard in this sense is included.

FAA-STD-013 (1)
FAA-STD-018 (1)
FAA-STD-026 (3)
FAA-STD-028 (2)
FAA Order 1810.4 - too difficult, need help (1)
DoD-STD-2167A - too general (5)
DoD-STD-2167A - vendor problems
DoD-STD-2167A - for maintenance
DoD-STD-2167A - produced too much documentation (5)
DoD-STD-2167A - for development; assumes good, solid requirements (1)

C.3.2 CONFLICTS

One subject thought there might be some conflicts with some FAA standards and DoD-STD-2167A.

C.3.3 DISCUSSION OF SPECIFIC STANDARDS

This section presents the issues pertaining specifically to standards. Included are the number of subjects associated with each issue.

C.3.3.1 FAA-STD-013a Quality Control Program Requirements (1)

It was reported that FAA-STD-013a has virtually been superseded by FAA-STDs 016a and 018a and should be either updated or eliminated.

C.3.3.2 FAA-STD-016a Quality Control Program Requirements (1)

It was reported that FAA-STD-106a is up to date, with the possible exception of some terminology, and is effective.

C.3.3.3 FAA-STD-018a Quality Control Program Requirements (3)

Three surveyed had an opinion on FAA-STD-018a but there was not general agreement. FAA-STD-018a was viewed by some as more effective than DoD-STD-2168, and in good shape and up to date (with the exception of some terminology). However, another subject thought it was too vague and not detailed enough. No one described the standard as poor, but some feel that it could use more detail.

C.3.3.4 FAA-STD-026 NAS Software Development (3)

FAA-STD-026 was viewed as an obstacle and source of trouble. It refers to DoD-STD-2167A and includes so many cross references that it makes tailoring DoD-STD-2167A difficult. It does not stand alone and provides little assistance in the development process. It is out of date and should be reworked or replaced.

C.3.3.5 FAA-STD-028 Contract Training Programs (3)

Opinion was divided on FAA-STD-028. However, all thought it took a great deal of effort to usefully interpret FAA-STD-028. In spite of this, one subject thought it was a good standard while the other two thought it was not good because of the difficulty in interpretation. Differences in interpretation within the FAA occur between headquarters and FAA Academy training personnel. It seems the common denominator is that FAA-STD-028 is not clear enough and possibly lacking in sufficient detail.

C.3.3.6 FAA Order 1810.4b FAA NAS Test and Evaluation Program(1)

One subject reported trouble with FAA Order 1810.4a. It was stated that this order was not understood by staff in both the Technical Center and FAA Headquarters.

C.3.3.7 DoD-STD-2167A Defense System Software Development (13)

Section C.4 below addresses DOD-STD-2167A in detail as a specific problem because it was the most widely discussed standard and the

one that presented the most concern to the subjects. Based on the amount and strength of the responses, DoD-STD-2167A serious attention by the FAA.

C.3.3.8 FAA Order 1100 (1)

One subject reported that the 1100 "series" was very useful.

C.3.3.9 FAA Order 6100 Quality Control (1)

One subject reported that the 6100 "series" was very useful.

C.4 SPECIFIC PROBLEMS

C.4.1 DoD-STD-2167A

DoD-STD-2167A was the most commonly mentioned source of problems mentioned in the interview activity. Ten out of twelve subjects mentioned DoD-STD-2167A specifically in conjunction with some form of problem. Specific problems cited with respect to DoD-STD-2167A were:

Too hard to use;

Need help in understanding DoD-STD-2167A;

Needed help in tailoring, and FAA-STD-026 got in the way during this process;

DoD-STD-2167A was misapplied;

DoD-STD-2167A documentation delivered, but not used;

DoD-STD-2167A resulted in too much documentation to review;

Although good for development, DoD-STD-2167A documents are not suited for maintenance - too hard to specify changes;
DoD-STD-2167A not adequate for interactive, real-time; and

DoD-STD-2167A loses the Computer Program Functional Specification (CPFS) concept, and the CPFS is important to the FAA.

The majority of those interviewed did not understand DoD-STD-2167A. They had little or no training in this area. They longed for tailoring guidelines or a group to help them tailor it. Tailoring was viewed as critical, and without it the standard would be, and was, misapplied. FAA-STD-026 hindered tailoring efforts because of

the numerous cross references to DoD-STD-2167A and other documents.

DoD-STD-2167A was viewed as producing a set of development documents rather than a set of maintenance documents. In addition to tailoring, the second major problem with DoD-STD-2167A was in using it as a maintenance document. It is hard to specify changes with DoD-STD-2167A since they are often scattered throughout the documents. The end-user (AT) cannot understand changes specified using DoD-STD-2167A. Most interviewed preferred using a CPFS for change specification. It was also stated that specifying Man-Machine Interfaces (MMIs) was difficult with DoD-STD-2167A. Since DoD-STD-2167A documents are not maintained by the FAA, they get increasingly out of date with time.

However, most users felt that with training, guidelines, and a maintenance CPFS, the use of DoD-STD-2167A would be effective.

Note: FAA-STD-018 was viewed as more effective than DoD-STD-2167A's companion SoS-STD-2168.

C.4.2 REQUIREMENTS

The problem of Air Traffic (AT) not accurately specifying or agreeing to requirements was the other dominant theme that surfaced during the interviews. The problems cited were:

Cannot get an firm requirements from AT;

AT does not pay attention until they can see it;

Lack of adequate guidelines for requirements production;

AT does not follow the rules with respect to requirements specification; and

Projects fail at the testing phase due to vague or "changed" requirements.

Virtually all interviewed, that had an opinion, felt that AT, the end user/customer, did an inadequate job in specifying or agreeing to requirements for FAA projects. Various reasons were offered for this problem: too much turnover of user personnel; lack of guidelines; too little time and budget allocated to the task; congressional specified deadlines; and lack of enforcement of FAA rules. Some stated that AT is incapable of developing requirements. The result of all this is that projects fail during testing due to requirements that are either vague or no longer what the customer wants. Some felt that prototyping might help, especially in the areas of MMIs. If done early and even separately from the project's main contract, it might serve as an aid to

requirements specification, This might solve the "AT doesn't know what it wants till it sees it" problem.

C.4.3 PROBLEMS WITH STANDARDS, ORDERS, AND GUIDELINES

In addition to the problems stated with DoD-STD-2167A above, several other problems with standards, orders, and guidelines surfaced during the interviews. Specifically mentioned were:

DoD-STD-2167A - addressed separately above; (13)

A lack of guidelines for dealing with COTS software; (5)

The high cost of retrofitting new standards to projects already underway; (2)

Some orders are out of date with respect to the FAA organization; (1)

FAA Order 1810.4 is hard to understand; (1)

A lack of coding standards for contractors; (1)

R,E&D organization doesn't follow any FAA Orders or Standards, thus mismatched equipment and systems in the NAS (1);

Difficulty in keeping up to date with FAA standards; (1)

There are no policies or standards with respect to air traffic controller training on new enhancements, thus quality varies greatly (1).

The DoD procurement approach caused problems with getting test plans too early; and (1)

Management was resistive to change - hard to get standards and orders updated. (1)

After DoD-STD-2167A, the most frequently mentioned problem with standards was missing guidelines for dealing with COTS software. Issues mentioned were: definition of a COTS software, how to deal with modification COTS software, and what documentation requirements are needed for COTS software.

Some problems with the management, maintenance, and distribution of standards were mentioned. Some orders were not kept up to date with changes in the FAA organization. Others cited management resistance to change as a reason for not keeping standards up to

date with the technology. Some of the interviewees cited difficulty in finding out which FAA standards exist and are applicable to their tasks. Keeping up to date with changes was also cited as difficult.

Two areas were identified where guidelines were missing. Coding standards exist within the FAA but are not applies to vendors. This results in code that is difficult to maintain.

Faa Order 1810.4 was cited as difficult and complex.

A case was cited with the DoD procurement policies which resulted in test plans being developed far too early.

C.4.4 FAA ORGANIZATION

Some problems with the FAA organizational staffing and resources were noted:

Too compartmentalized - lack of communication between groups within the FAA;

No group to handle project interfaces - lack of overall system engineering;

Difficulties with lack of trained software people in the project and other offices and difficulty in maintaining software project skills in the project office;

Lack of emphasis for minimizing life cycle project costs;

Lack of software skills within the QA staff; and

Wrong group is contacted by Program Manager when determining requirements for standards documents on a project.

Two issues concerning the FAA's organization and staffing profile showed up. A lack of competent software engineering staff in the project office, software support and QA function was specifically mentioned with some mention of the same problem in most all other areas. The software background discussed covers: life cycle software project management and software engineering.

Even if the problem were solved, it was believed that individuals in these positions would either lose these skills or leave these positions. The possibility of a "rotation shift" was mentioned. There was some mention of training, but some felt that hiring in the necessary skills would be more effective than training existing staff members.

The other issue concerns the life cycle cost of FAA projects. It was mentioned that not enough concern for the life cycle cost of the project was shown in budgeting effort allocations to the various phases of the development cycle. A lack of concern for the life cycle cost, especially in the earlier phases of the development effort, was also cited. The Faa was described as too compartmentalized, which may correspond to the cited lack of concern for life cycle cost.

Another issue raised was the FAA's apparent approach to project management by letting standards, rather than direct involvement, control the project.

C.4.5 QUALITY ASSURANCE (QA)

QA was mentioned, but no solid concerns were evident. The lack of software engineering skills by the QA staff, as well as not enough early involvement in project, were both mentioned.

C.5 LIFE CYCLE ANALYSIS

This section examines the various phases of the NAS life cycle. In some cases, references will be made to the life cycle stages presented in Figure 1-1 of this report.

C.5.1 REQUIREMENTS DETERMINATION

C.5.1.1 Strengths

Only one person stated that the requirements definition process works well and then it was qualified with the statement "if the requirements are worked out and an NCP is generated".

C.5.1.2 Weaknesses

The requirements determination phase of the NAS life cycle was unanimously named the worst phase of the life cycle by those subjects who had an opinion. The major problems that were cited are:

A general lack of standards defining the requirements determination phase;

Little or no participation by AT during the requirements determination phase;

Not enough early involvement during the requirements phase by QA and maintenance; and

ATO reacts to daily situations which keeps changing the requirements;

The real air traffic controllers are not defining the requirements;

Not enough time allocated for a thorough job of requirements determination.

Most of the subjects put the blame on AT for the problems in this phase. It was stated that AT does not obey the rules and lets engineering develop the requirements. Then AT approves them without adequate review. The other approach is that AT states very general and vague requirements. Finally, when AT can "see" the product (typically during testing during phase 2.6, DT&E). it then defines the real requirements for the project.

No one denied that the requirements definition phase is very difficult.

There seems to be no clear transition from phase 1 to phase 2, which allows poor requirements to leak through to the next phase. One subject suggested some form of Procurement Readiness Review to help verify the quality of the requirements statement.

Human factors (MMIs) were cited as very difficult to specify in a requirement document. prototyping was mentioned as one useful to help this difficult task. See Section C.7 for more details on prototyping.

C.5.2 ACQUISITION

C.5.2.1 Strengths

The acquisition phase was named as the best phase in the NAS life cycle. However, it was cited as adequate, but not outstanding.

One subject noted that programming standards are not applied to the contractors during this phase which hurts system maintenance.

Demonstrations were mentioned as a good way of determining the software's condition.

C.5.2.2 Weaknesses

The testing guidelines were cited by several subjects as being too vague and wordy.

One subject noted the differences between the rules and actual practice but did not cite any specific instances. Other subjects noted that often the guidelines were not followed for several reasons. Sometimes the orders were out of date and in other cases, standards and guidelines were simply ignored.

It was noted that the standards and orders applicable during this

phase sometimes get out of date with respect to the FAA's organizational structure.

C.5.3 OPERATIONAL SUPPORT

C.5.3.1 Strengths

This phase appears to function adequately with a few exceptions. Most of the problems expressed were a result of problems with the earlier phases and not inherent problems with this phase. One subject stated that this was the best phase because it stops projects until the customer is happy - even though the system may meet the specifications.

C.5.3.2 Weaknesses

Maintenance was viewed as hard for a number of reasons, most of them originating with the use of DoD-STD-2167A documentation and the lack of a CPFS in the acquisition phase. It was noted that, due to the use of separate organizations to support hardware and software, that maintenance became political and somewhat difficult.

C.5.4 PHASE TRANSITIONS

Both phase transitions were viewed as weak points within the NAS life cycle. There are not clearly understood rules for defining these transitions.

Apparently, there are no standards, orders, etc., for defining these transitions, nor formal procedural methods for insuring the adequacy of one phase before moving to the next. It was suggested that an approach similar to that used for a Deployment Readiness Review (DRR) would be useful in evaluating the transition from one phase to another.

C.5.4.1 Phase Transition: Requirements Determination (1) to Acquisition (2)

This transition, although scheduled, never really occurred. Phase 2 begins before phase 1 is completed. Then the two phases both continue until they both merge into phase 3. A requirements determination is completed before phase 2 begins; however, the requirements determination is performed by engineering, not the customer (AT). At does have to approve the requirements documents, but apparently does not thoroughly review the document; they have not decided themselves what is necessary. When testing begins, the "real requirements" come out and, most often, the real requirements are different than those used to design and build the system. Obviously, this results in a large amount of costly rework.

There are rules concerning the development of a requirements document, but they are apparently not followed by At during various

stages of phase 1 and 2.

C.5.4.2 Phase Transition: Acquisition (2) to Operational Support (3)

The phase 2 to 3 transition, although not as much a problem as the phase 1 to 2 transition, does cause some problems. The testing operation is guided by a vague set of rules and the exact criteria for going to phase 3 is not defined.

[NOTE: The Software Integration Working Group (SIWG) is in the process of preparing a "Procured Software Hand-off Procedure" Action Notice which addresses the transition from phase 2.0 to 3.0]

C.6 DOCUMENTATION

C.6.1 PROBLEMS ENCOUNTERED

The majority of problems cited concerning documentation were related to the use of DoD-STD-2167A. This standard, often misapplied, results in documentation that is not appropriate for system maintenance and is often of such volume that it is not thoroughly reviewed. The use of DoD-STD-2167A also causes trouble for the FAA when it tries to tailor the standard. Section C.4 of this document contains a thorough discussion of the problems with DoD-STD-2167A.

C.6.2 OTHER TOPICS

The Government Printing Office (GPO) often reformats and publishes documents produced by vendors. This is obviously expensive and time-consuming. It would be desirable if the vendors could deliver their documentation in machine readable form (Interleaf was mentioned).

It was not clear how to handle COTS documentation. The subjects were not clear concerning which COTS documentation is required on a project.

Sometimes it is cheaper not to require a full set of documentation but rather to obtain needed documents on a case basis. 2167A seems good for development documentation but not maintenance. Since the DoD-STD-2167A documents are not kept up to date, some documentation must be maintained in order to support maintenance. Many subjects recommended that the CPFS, used before DoD-STD-2167A appeared, would be the right candidate for a maintenance document. The large amount of documentation produced by DoD-STD-2167A created more work than the FAA could handle and often was ignored by the FAA.

Many of these DoD-STD-2167A problems can be solved by tailoring the standard, but few subjects interviewed knew how to tailor DoD-STD-

2167A.

Guidelines are clearly needed to help the FAA staff deal with COTS software documentation. This was discussed in the standards section above.

C.7 PROTOTYPING

Prototyping was generally viewed as a useful and desirable activity. It was most often cited for use in MMIs and once for real-time signal processing.

Three advantages to prototyping were cited: (1) it is useful for new systems where the activity borders on R&D; (2) it helps "firm-up" requirements; and (3) demonstrations of prototypes may help get AT more interested and involved since they can actually see the product.

The downside of prototyping is the cost of prototyping in an accurate simulated environment of AT. A critical evaluation is difficult to do without a simulated environment.

C.8 METHODOLOGY SPECIFICATION

There seems to be no demand for the FAA to require a specific methodology of the vendors. There was concern that the documentation and other standards would provide sufficient assurance of this.

C.9 SPECIFIC RECOMMENDATIONS BY THE INTERVIEWEES

This section presents the specific recommendations that were made during the interview process by the interviewees. Only the recommendations explicitly made are presented here, therefore this section is not a summary of the interview process.

The specific recommendations were:

> Standards, especially DoD-STD-2167A, should be tailored;
>
> There should be a support group within the FAA to assist in tailoring;
>
> The CPFS concept should be brought back;
>
> A draft CPFS should be done very early in the project. It helps the requirements analysis phase;
>
> Do not retrofit new guidelines to existing projects;

Enforce existing standards and orders;

Test in an integrated environment in phase 2.7 (see Figure 1-1), rather than just during phase 3;

Have QA and maintenance become involved early in projects;

Put incentives in place for minimizing life cycle costing;

Get more qualified software people in project office, QA, and elsewhere;

Develop standards for dealing with COTS and non-developmental software (NDS);

Apply FAA coding standards to contractors;

Develop firm criteria (standards) for moving from phase to phase; and

Do away with or heavily revise FAA-STD-026.

Do more tailoring of standards.

Provide software engineering concepts training.

Each of these issues have been discussed in other sections of this report.

APPENDIX D

LIFE CYCLE ELEMENTS

VERSUS

GOVERNING DOCUMENTS

SOFTWARE ENGINEERING ITEM	GOVERNING FAA-STD-	GOVERNING FAA ORDER	GOVERNING OTHER
Acceptance Testing		1810.4b	
Acquisition		1800.8f	
Allocated Baseline	021a	1800.8f	
Allocated Configuration Identification; ACI	021a		
Air Traffic Configuration Control Board; AT CCB		1800.8f	
Audits	016a 018a	1800.8f	
Automated Tools			
Baseline(s)	021a		
Case Files		1800.8f 1100.134a	Form 1800-15 Form 1800-17
Change Status Report	021a		
Cluster CCBs (see Division CCB)		1800.8f	
Code Standards	026		
Commercial Off-The-Shelf (COTS) Software		1800.8f	
Compilers			A.N.1370.9
Computer Program Functional Specification	026		
Computer Resource Integrated Support Document	026		
Computer Security		1600.54b	
Computer Software Component; CSC	026		
Computer Software Configuration Index	021a		
Computer Software Configuration Item; CSCI	026		
Computer Software Quality Program	018a	4630.9	
Computer Software Quality Program Plan; CSQPP	018a	4630.9	
Computer Software Unit; CSU	026		
Computer System Operator's Manual	026		
Concept Analysis			
Concept Definition and Verification		1800.8	
Configuration Audits		1800.8f	MIL-STD-1521B
Configuration Control	021a	1800.8f 1800.25	MIL-STD-480 MIL-STD-481
Configuration Control Board		1800.8f	
Configuration Control Decisions	021a, 026	1800.8f	Form 1800-49
Configuration Control Procedures		1800.8f	
Configuration Control Support Facility		1800.25	
Configuration Management Audits	021a		
Configuration Management Plan	021a		
Configuration Management Procedures	021a	1800.8f	

SOFTWARE ENGINEERING ITEM	GOVERNING FAA-STD-	GOVERNING FAA ORDER	GOVERNING OTHER
Corrective Action Process	026		
Cost Modeling			
Cost/Schedule Report	026		
Critical Design Review	026	1800.8f	MIL-STD-1521
CSC Integration and Testing	026		
CSCI Testing	026		
CSU Testing	026		
Database Design Document	021a		
Database Management			
Deployment Readiness Review; DRR		1800.8f 1810.4b	
Design Baseline	021a	1800.8f	
Design Configuration Identification; DCI	021a		
Design Standards	026		
Detailed Design	026		
Developmental Configuration			
Developmental Test and Evaluation Plan		1810.4b	
Developmental Test and Evaluation Procedures		1810.4b	
Developmental Test and Evaluation Test Report		1810.4b	
Discrepancy Reports	026		
Division Configuration Control Board		1800.8f	
Documentation	005		
Documentation Management			
DRR Memorandum		1800.	
DRR Monthly Status Report		1800.	
DRR Report		1800.	
Engineering Change Proposals	026, 021a		
Engineering Release	021a		
FCA/PCA Plan		1800.8f	
Field Shakedown Testing		1810.4b	
Firmware Support Manual	026		
Formal Qualification Review; FQR	021a	1800.8f	
Formal Qualification Testing	026		
Functional Baseline	021a	1800.8f	
Functional Configuration Audit; FCA	026	1800.8f	MIL-STD-1521
Functional Configuration Identification; FCI	021a		
Hand-off Package		1800.8f	

SOFTWARE ENGINEERING ITEM	GOVERNING FAA-STD-	GOVERNING FAA ORDER	GOVERNING OTHER
Implementation	026		
Independent OT&E for MSA		1810.3	
Independent Verification and Validation; IV&V	026, 018a	4630.9	
Integration and Testing	026		
Interface Control Document; ICD	025		
Interface Design Document	026	1810.4b	
Interface Management		1810.4b	NAS-SS-1000
Interface Requirements Document; IRD	025	1810.4b	
Interface Requirements Specification	026, 005d		MIL-STD-490A
Key Decision Memorandum		1810.1d	
Key Decision Point		1810.1d	OMB Circular A-109
Languages	026		A.N.1370.9
Logistics	034	1800.58	
Maintenance Engineering Configuration Control Board; ME CCB		1800.8f	
Management	026		
Major System Acquisition		1810.1d	Order 4200.14b
Master Test Plan; MTP	024	1810.4b	
Memorandum of Understanding; MOU		1810.4b	
Mission Analysis			
Monthly Management Review			
Monthly Progress Reports	026		
NAS Change Proposals		1800.8f	Form 1800-2
NAS Configuration Control Board; NAS CCB		1800.8f	
NAS Life Cycle		1800.8f	
NAS System Requirements Specification	005d		
Non-Developmental Software; NDS	026		
Operating Systems			
Operational Support		1800.8f	
Operational Test and Evaluation; OT&E	024	1810.2	
Operational Test and Evaluation Integration Test Report		1810.4b	
Operational Test and Evaluation Plan	024	1810.4b	
Operational Test and Evaluation Procedures	024	1810.4b	
Operational Test and Evaluation Shakedown Test Report		1810.4b	
Operational Transition			
Physical Configuration Audit; PCA	026	1800.8f	MIL-STD-1521B

SOFTWARE ENGINEERING ITEM	GOVERNING FAA-STD-	GOVERNING FAA ORDER	GOVERNING OTHER
Portable Software			
Portability			
Post Deployment Support		1100.134a 1100.145 1800.8f	
Preliminary Design	026		
Preliminary Design Review	026	1800.8f	MIL-STD-1521
Problem/Change Report	026		
Problem Technical Report		1100.134a	
Problem Tracking and Reporting	026		
Procurement Request	030	1800.	
Product Baseline	021a	1800.8f	
Product Configuration Identification; PCI	021a		
Product Specification	005d		
Production Acceptance Test and Evaluation Plan		1810.4b	
Production Acceptance Test and Evaluation Procedures		1810.4b	
Production Acceptance Test and Evaluation Test Report		1810.4b	
Program Authorizations; PA			
Program Definition			
Program Directives; PD		1810.1d 1810.4b	
Program Management Plan		1810.4b	
Program Master Plan; PMP		1810.1d	
Program Plan			
Program Technical Report; PTR		1800.8f	Form 6100-1
Programmatic Baseline		1800.8f	
Project Implementation Plan	036		
Project Initiation			
Project Management Plan		1810.4b	
Project Plan			
Prototyping			
Quality Assurance	018a 016a	4630.9 4630.8	
Quality Assurance Report	018a	4630.9	
Quality Control	016a,018a	4630.9	
Quality Control Procedures			
Quality Control Program Plan			
Quality Control System Plan	016a	4453.2a	NO. 00-41A
Quarterly Review		1810.1d	

SOFTWARE ENGINEERING ITEM	GOVERNING FAA-STD-	GOVERNING FAA ORDER	GOVERNING OTHER
Quarterly Status Reports		1810.1d	
Rapid Prototyping			
Records	018a	4630.9	
Regional Configuration Control Board		1800.8f	
Reports	018a	4630.9	
Request For Proposal	030		
Requirements Definition	026	1810.1d	NAS-SR-1000
Requirements Determination		1800.8f	
Requirements Traceability matrix		1800.8f	
Research, Engineering and Development			
Resource Performance Analysis			
Reviews	026	1800.8f	MIL-STD-1521
Risk Management	026		
Risk Analysis			
Risk Management Plan	026		
Safety Analysis	026		
Security		1600.54b	
Shake-Down Testing		1810.4b	
Site Adaptation		1800.8f	
Software Acquisition Plan			
Software Code Standards			
Software Configuration Management			
Software Configuration Management Plan	021a, 026	1800.8f	
Software Cost Estimates			
Software Estimating			
Software Design Document	026		
Software Design Standards			
Software Detailed Design Document	026		
Software Development Environment			
Software Development File	026		
Software Development Folder	026		
Software Development Library	026		
Software Development Management	026		
Software Development Methods	026		MIL-STD-1521
Software Development Plan	026		
Software Development Tools			
Software Documentation Management			

SOFTWARE ENGINEERING ITEM	GOVERNING FAA-STD-	GOVERNING FAA ORDER	GOVERNING OTHER
Software Engineering	026		
Software Engineering Environment	026		
Software Languages	026		
Software Management	026		AFSCP 800-43
Software Management Plan	026		AFSC Pamphlet
Software Maintenance		1100.124	
Software Maintenance Plan			
Software Methodology	026		
Software Metrics			
Software Portability			
Software Product Evaluation	026		
Software Product Specification	026,005d		MIL-STD-490A
Software Programmer's Manual	026		
Software Quality Assurance Report	018a,016a	4630.9	
Software Quality Program Plan	018a,016a	4630.9	
Software Quality Control Procedures	018a,16a	4630.9	
Software Requirements Specification; SRS	026		
Software Requirements Review	026		
Software Reuse			
Software Reviews	026		MIL-STD-1521
Software Risk Analysis			
Software Schedules			
Software Security	026		
Software Specification Review	026	1800.8f	MIL-STD-1521
Software Standards and Procedures Specification	026		
Software Technology			
Software Test Descriptions	026		
Software Test Environment	026		
Software Test Management			
Software Test Plan	026		
Software Test Procedures			
Software Test Reports			
Software Tools			
Software Top Level Design Document	026		
Software Transition			
Software Transition Plan			

SOFTWARE ENGINEERING ITEM	GOVERNING FAA-STD-	GOVERNING FAA ORDER	GOVERNING OTHER
Software User's Manual	026		
Source Code	026		
Specification Change Notices	021a, 026, 005d		
Specification Review Board		1800.8f	
Specifications	005d	1800.8	NAS-SS-1000
Statement of Work	031		
Subcontractor Management	026		
System Design Review; SDR	026	1800.8f	MIL-STD-1521b
System Engineering		1800.8f	
System Life Cycle		1800.8f	
System Integration and Testing			
System Requirements Review	026	1800.8f	MIL-STD-1521B
System Requirements Specification	026	1800.8f	MIL-STD-499 MIL-STD-490A
System Requirements Statement; SRS		1810.1d	
System Security	026		
System Specification			
System Test Plan			
System Test Procedures			
Systems Engineering Configuration Control Board; SE CCB		1800.8f	
System/Segment Design Document			
System/Segment Specification	005d		
Technology Envaluation Reports	024	1810.4b	
Test and Evaluation Reports	024	1810.4b	
Test Documents	016a		
Test Management	024	1810.4b	
Test Readiness Review	026	1800.8f	MIL-STD-1521
Tools			
Traceability Matrix	026		
Training	028	3120.4	
Training Materials	028		
Training Plan	028		
Transition Plan			
Transition to Software Support	026		
TSARC Program List		4400.56	Order 4200.9A
Validation & Verification	026		
Verification			NAS-SS-4000

SOFTWARE ENGINEERING ITEM	GOVERNING FAA-STD-	GOVERNING FAA ORDER	GOVERNING OTHER
Verification Requirements Traceability Matrix; VRTM		1810.4b	
Version Description Document	026		
Work Breakdown Structure			

APPENDIX E

EXPANDED NAS SYSTEM LIFE CYCLE

EXPANDED NAS SYSTEM LIFE CYCLE

1.0 REQUIREMENTS DETERMINATION: (all FAA activities)

1.1 CONCEPT DEFINITION AND VERIFICATION

1.1.1 Products:

System Level Operational Concept Documents
R,E&D Program Plans
R,E&D Project Plans
System Specification, Program (initial)
Functional Specification

1.1.2 Reviews:

Monthly Management Reviews

1.1.3 Actions:

Concept analyses
Mission analyses
Technology application studies

1.2 PROGRAM DEFINITION (MSA: Requirements Definition)

1.2.1 Products:

NAS SYSTEM LEVEL:

NAS Requirements Document (initial)
NAS System Requirements Specification (baselined)
NAS Level I Design (functional baseline)
NAS System Specification (allocated baseline)
(also called NAS Level II Design)
NAS Transition Plan (initial)
(also called NAS Level III Design)
NAS Interface Requirements Document (baselined)

PROGRAM SYSTEM LEVEL:

Major System Acquisition Candidate Statement
Mission Need Statement (for program not in NAS Plan)
System Requirements Statement; SRS (initial)
Key Decision Memorandum; KDM (initial)
Acquisition Paper; AP
Program Directives (for testing)
Clearance Records (T&E)
Program Management Plan; PMP
(also called Program Master Plan,
Project Management Plan 1810.1d)

System Specification (baselined)
(also called Project Specification,
Program Specification)
Master Test Plan; MTP (initial)
(includes Verification Requirements Traceability Matrix; VRTM)
Request for Proposal
Work Breakdown Structure
Configuration Control Decisions (CCD)
Case Files
Statement of Work (SOW)
NAS Change Proposals
Risk Management Plan
Contract Training Proposals

SOFTWARE:

Software Acquisition Plan
Software Management Plan
Software Configuration Management Plan (initial)
Software Maintenance Plan (initial)
Software Transition Plan (initial)

1.2.2 Reviews:

NAS SYSTEM LEVEL:

NAS System Requirements Review
NAS System Engineering Configuration Control Board; CCB
Quarterly Review

PROGRAM SYSTEM LEVEL:

Monthly Management Review
Specification Review Board (SRB)
System Engineering CCB
Test Policy & Planning Review Board (TPRB) meeting
(MTP review)

SOFTWARE:

TBD

1.2.3 Actions:

NAS SYSTEM LEVEL:

Designate a program as a Major System Acquisition or not a MSA

appoint Program Sponsor
appoint Program Manager
approve Program Manager charter

PROGRAM SYSTEM LEVEL:

Identify training requirements (for FAA personnel)
Define Operational Test and Evaluation OT&E) Integration and Shakedown requirements
Define Production Acceptance Test and Evaluation (PAT&E) requirements
Validate Deployment Readiness Review (DRR) items in the solicitation package

SOFTWARE:

Assess software technology requirements

1.2.4 Key Decision Point (KDP) #1 For MSA:

Authorizes program to proceed to Concept Analysis

2.0 ACQUISITION: (contractor activities except items with * are FAA activities)

2.1 PROJECT INITIATION (MSA: Concept Analysis)

2.1.1 Products:

SYSTEM LEVEL:

Program Management Plan
Configuration Management Plan (initial)
Quality Control Program Plan; QCPP (initial)
Quality Control System Plan; QCSP (initial)
System/Segment Design Document; SSDD (initial)
(also called System/Segment Specification; SSS)
Risk Management Plan (initial)
Training Plan (initial)
Monthly Progress Reports; Cost/Schedule Reports
Engineering Change Proposals (ECP)
(also called Engineering Change Requests - 018a)
Specification Change Notices (SCN)
Configuration Control Decisions (CCD)
*System Development Contract
*Quarterly Status Reports
*Test Management Plan

SOFTWARE:

Software Development Plan (initial)
(includes Software Engineering Environment Plan)
Software Requirements Specification (initial)
Interface Requirements Specification (initial)
Software Configuration Management Plan (initial)
Computer Software Quality Program Plan; CSQPP (initial)
Software Standards and Procedures Specification (initial)
(includes software design and code standards)
Traceability Matrix; System Spec., SOW (initial)

2.1.2 Reviews:

SYSTEM LEVEL:

Monthly Management Review
System Requirements Review
Program/project CCB
*Quarterly Reviews

SOFTWARE:

Software Specification Review; SSR

2.1.3 Actions:

SYSTEM LEVEL:

TBD

SOFTWARE:

Software methodology selection
Software tools selection
Language selection
Operating System selection
Build versus buy decisions
Software metrics selection
Software Tools demonstrations
  Configuration Control Tool
  Software Development Library
  Traceability Matrix Tool
  Problem Tracking and Reporting Tool
  Software development tools (compilers, etc)

2.2 REQUIREMENTS DEFINITION (MSA: Concept Analysis)

2.2.1 Products:

SYSTEM LEVEL:

Configuration Management Plan (baselined)
Quality Control Program Plan; QCPP (baselined)
Quality Control System Plan; QCSP (baselined)
System/Segment Design Document; SSDD (baselined)
  (or System/Segment Specification; SSS (baselined))
Risk Management Plan (baselined)
System Test Plan; STP (initial)
  (this is the Development Test and Evaluation (DT&E) Plan)
Monthly Status Reports
Contract Training Plan
Computer System Diagnostic Manual
System Allocation Document
Computer Resource Integrated Support Document; CRISD (initial)
*Quarterly Status Reports

SOFTWARE:

Software Development Plan (baselined)
Software Requirements Specification (baselined)
Software Configuration Management Plan (baselined)
Computer Software Quality Program Plan (baselined)
Software Standards and Procedures Specification (baselined)
Software Quality Control Procedures (initial)
Interface Requirements Specification (baselined)
Traceability Matrix (SSDD, SRS, IRS)
Software Quality Assurance Reports
Computer Program Functional Specification; CPFS (initial)

2.2.2 Reviews:

SYSTEM LEVEL:

Monthly Management Review
System Requirements Review; SRR
System Design Review; SDR
*Quarterly Review

SOFTWARE:

Software Specification Review; SSR
Software Products Evaluations; SDP, SSDD, SRS, IRS

2.2.3 Actions:

SYSTEM LEVEL

Submit Engineering Change Proposals (ECP)
Configuration Control Board acts on ECPs
Establish project Problem Tracking and Reporting database
Financial Data Analysis
Training Course Task Analysis

SOFTWARE:

Establish project Software Development Library
Software Metrics Analysis

2.3 PRELIMINARY DESIGN (MSA: Concept Analysis)

2.3.1 Products:

SYSTEM LEVEL:

Monthly Status Reports
Training Plan (baselined)
System Test Plan; DT&E (baselined)
System Test Procedures; DT&E (initial)
Training Materials (initial)
Contract Training Plan
*Master Test Plan (baselined)
*Quarterly Status Reports
*Key Decision Memorandum (updated)

SOFTWARE:

Software Quality Control Procedures (baselined)
Software Test Plan (initial)
(includes Software Test Environment Plan)
Interface Design Document; IDD (initial)
Software Top Level Design Document; STLDD (initial)
Traceability Matrix (updated - STLDD)
Software Development Files; STLDD
(also called Software Development Folders - 018a)
Software Quality Assurance Reports
Computer Program Functional Specification; CPFS (baselined)

2.3.2 Reviews:

SYSTEM LEVEL:

Monthly Management Reviews
*Quarterly Review

SOFTWARE:

Software Product Evaluations; STLDD
Preliminary Design Review (PDR)
Configuration Management Audits

2.3.3 Actions:

SYSTEM LEVEL:

Financial Data Analysis
Submit Engineering Change Proposals (ECP)
Configuration Control Board acts on ECPs

SOFTWARE:

Resource Performance Analysis
Software Metrics Analysis

2.3.4 KDP #2 for MSA:

*Authorizes program to proceed to Demonstration Phase

2.4 DETAILED DESIGN (MSA: Demonstration Phase)

2.4.1 Products:

SYSTEM LEVEL:

Monthly Status Reports
System User's Guide (training)
Course Design Guide (training)
*Quarterly Status Reports

SOFTWARE:

Software Test Plan; STP (baselined)
Interface Design Document, Top Level; TLIDD (baselined)
Software Top Level Design Document; STLDD (baselined)
Software Test Descriptions, Cases (initial)
Software Detailed Design Document; SDDD (initial)
Interface Design Document, Detailed; DIDD (initial)
Traceability Matrix (updated - SDDD)
Software Quality Assurance Reports
Software Development Files (updated - SDDD, CSC)

2.4.2 Reviews:

SYSTEM LEVEL:

Monthly Management Reviews
*Quarterly Review

SOFTWARE:

Critical Design Reviews (CDRs)
Configuration Management Audits

2.4.3 Actions:

SYSTEM LEVEL:

Submit Engineering Change Proposals (ECP)

Configuration Control Board acts on ECPs

SOFTWARE:

Resource Performance Analysis
Software Metrics Analysis
Configuration Control; STP, TLIDD, STLDD

2.5 IMPLEMENTATION (MSA: Demonstration Phase)

2.5.1 Products:

SYSTEM LEVEL:

System Test Procedures; DT&E (baselined)
Production Acceptance Test and Evaluation Plan; PAT&E (initial)
Monthly Status Reports
*Operational Test and Evaluation Plan; OT&E (initial)
*OT&E Procedures (initial)
*Quarterly Status Reports

SOFTWARE:

Source Code
Computer System Operator's Manual; CSOM
Software Programmer's Manual; SPM
Firmware Support Manual; FSM
Software Detailed Design Document; SDDD (baselined)
Software User's Manual; SUM (initial)
Software Test Descriptions, procedures (initial)
Traceability Matrix (updated - source code)
Software Quality Assurance Reports
Software Development Files (updated - CSU)

2.5.2 Reviews:

Monthly Management Reviews
*Quarterly Review

2.5.3 Actions:

Resource Performance Analysis
Software Metrics Analysis
Configuration Control; SDDD, DIDD, STD, CSU
Submit Engineering Change Proposals (ECP)

Configuration Control Board acts on ECPs

2.6 INTEGRATION AND TESTING (MSA: Demonstration Phase)

2.6.1 CSC Integration and Testing:

2.6.1.1 Products:

SYSTEM LEVEL:

Monthly Status Reports
*Quarterly Status Reports

SOFTWARE:

Software Test Reports
Traceability Matrix (updated - CSC tests)
Software Quality Assurance Reports
Software Development Files (updated - CSC tests)

2.6.1.2 Reviews:

Monthly Management Review
*Quarterly Review

2.6.1.3 Actions:

Submit Engineering Change Proposals (ECP)
Configuration Control Board acts on ECPs

2.6.2 CSCI Testing:

2.6.2.1 Products:

SYSTEM LEVEL:

Monthly Status Reports
*Quarterly Status Reports

SOFTWARE:

Software Test Reports
Traceability Matrix (updated - CSCI tests)
Software Quality Assurance Reports
Software Development Files (updated - CSCI tests)

2.6.2.2 Reviews:

Monthly Management Review
*Quarterly Review

2.6.2.3 Actions:

Submit Engineering Change Proposals (ECP)
Configuration Control Board acts on ECPs

2.6.3 System Integration and Testing:

2.6.3.1 Products:

SYSTEM LEVEL:

Monthly Status Reports
DT&E Procedures (baselined)
PAT&E Plan (baselined)
PAT&E Procedures (initial)
*Project Implementation Plan
*OT&E Plan (baselined)
*OT&E Procedures (baselined)
*Quarterly Status Reports
*Key Decision Memorandum (updated)

SOFTWARE:

Software Test Reports
Software User's Manual; SUM (baselined)
Software Test Descriptions, procedures (baselined)
Training Materials (baselined)
Version Description Documents (initial)
Software Product Specifications (initial)
Traceability Matrix (updated - system test procedures)
Software Quality Assurance Reports

2.6.3.2 Reviews:

Monthly Management Review
*Quarterly Review
*Test Readiness Review

2.6.3.3 Actions:

Submit Engineering Change Proposals (ECP)
Configuration Control Board acts on ECPs
Functional Configuration Audit (FCA)
Physical Configuration Audit (PCA)

2.6.4 KDP #3 for MSA:

*Authorizes program to proceed with full scale development and limited production; return to Step 2.0.

2.7 FACTORY ACCEPTANCE TESTING (DT&E)

2.7.1 Products:

SYSTEM LEVEL:

DT&E Test Reports
Monthly Status Reports
*Quarterly Status Report
*Test Support Memorandum of Understanding; MOU (initial)

SOFTWARE:

Updated source code
Version Description Documents (baselined)
Software Product Specifications (baselined)
Traceability Matrix (updated - all)
Computer Resource Integrated Support Document; CRISD (initial)
Software Quality Assurance Reports

2.7.2 Reviews:

Functional Configuration Audit (FCA)
Physical Configuration Audit (PCA)
Monthly Management Review
*Quarterly Review

2.7.3 Actions:

Formal Qualification Testing (FQT)
Configuration Control Board acts on ECPs

3.0 OPERATIONAL SUPPORT (contractor and FAA activities)

3.1 OPERATIONAL TRANSITION

3.1.1 Operational Test and Evaluation/Integration Testing:

3.1.1.1 Products:

Computer Resource Integrated Support Document; CRISD (baselined)
*Program Directives
*Memorandum of Understanding; MOU (final)
*OT&E Integration Test Report
*Quarterly Status Reports
*DRR Memorandum (announce DRR Team Meeting)

3.1.1.2 Reviews:

Monthly Management Review
*Quarterly Review

3.1.1.3 Actions:

Initial review of DRR checklist

3.1.2 Operational Test and Evaluation/Shakedown Testing:

3.1.2.1 Products:

*Quarterly Status Reports
*OT&E Shakedown Test Reports
*DRR Team Meeting Report
*DRR Monthly Status Report

3.1.2.2 Reviews:

Monthly Management Review
*Quarterly Review
*Deployment Readiness Review (DRR)

3.1.2.3 Actions:

TBD

3.1.3 Production Acceptance Test and Evaluation:

3.1.3.1 Products:

PAT&E Test Reports
*Quarterly Status Reports

3.1.3.2 Reviews:

Monthly Management Review
*Quarterly Review

3.1.3.3 Actions:

TBD

3.1.4 Site Field Shakedown Test and Evaluation:

3.1.4.1 Products:

*T&E Reports
*Quarterly Status Reports
*Key Decision Memorandum (updated)
*DRR Team Meeting Report
*DRR Monthly Status Report

3.1.4.2 Reviews:

Monthly Management Review
*Quarterly Review
*Deployment Readiness Review (DRR)

3.1.4.3 Actions:

System Commissioned

3.1.5 KDP #4 for MSA:

*Authorizes program to proceed with full production, installation, and operation of the system.

3.2 POST DEPLOYMENT SUPPORT

3.2.1 Products:

Problem Technical Report (PTR)
Case File
NAS Change Proposals
Updated source code
Updated documentation (what documentation?)

3.2.2 Reviews:

Monthly Management Review

3.2.3 Actions:

Live environment shakedown testing

APPENDIX F

REFERENCES

APPENDIX F

REFERENCES

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(e) memo; A.Cocanower, "Proposed Software Handback Requirements", 7 December 1988

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(n) no author, "Software Coordination Group (SCG) Management and Operating Plan", July 11, 1988

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APPENDIX G

GLOSSARY/ACRONYMS

APPENDIX G

GLOSSARY/ACRONYMS

AAF	Associate Administrator for Airway Facilities
AAP	Automation Service
ACD	Engineering, Research and Development Service
ACI	Allocated Configuration Identification
ACN	Engineering, Test and Evaluation Service
ADS	Advanced System Design Service
AHT	Office of Training and Higher Education
ALG	Logistics Service
AMC	Management Control Service
ASA	Advanced System Acquistion Service
ASE	System Engineering and Program Management Office
ASM	Systems Maintenance Service
AT	Air Traffic
ATC	Air Traffic Control
ATR	Air Traffic Plans and Requirements Service
CCB	Configuration Control Board
CDR	Critical Design Review
CM	Configuration Management
COTS	Commercial Off-the-Shelf
CPFS	Computer Program Functional Specification
CRISD	Computer Resources Integrated Support Document
CSC	Computer Software Component
CSCI	Computer Software Configuration Item
CSOM	Computer Software Operator's Manual
CSQPP	Computer Software Quality Program Plan
CSU	Computer Software Unit
DBDD	Database Design Document
DCI	Design Configuration Identification
DID	Data Item Description
DOD	Department of Defense
DRR	Deployment Readiness Review
FAA	Federal Aviation Administration
FCA	Functional Configuration Audit
FCI	Functional Configuration Identification
FQR	Formal Qualification Review
FSM	Firmware Support Manual
GFS	Government Furnished Software

ICD	Interface Control Document
IDD	Interface Design Document
IRD	Interface Requirements Document
IRS	Interface Requirements Specification
IV&V	Independent Verification and Validation
LSA	Logistics Support Analysis
MOU	Memorandum of Understanding
MTP	Master Test Plan
NAS	National Airspace System
NDS	Non-developmental Software
OSD	Operation and Support Document
OT&E	Operational Test and Evaluation
PCA	Physical Configuration Audit
PCI	Product Configuration Identification
PD	Program Directives
PDR	Preliminary Design Review
PMP	Program Master Plan
PTR	Program Technical Report
QA	Quality Assurance
QC	Quality Control
SDD	Software Design Document
SDDD	Software Detailed Design Document
SDF	Software Development Files
SDP	Software Development Plan
SDR	System Design Review
SE	System Engineering
SPM	Software Programmer's Manual
SRS	Software Requirements Specification
SRS	System Requirements Statement
SSDD	System/Segment Design Document
SSS	System/Segment Specification
SUM	Software User's Manual
STD	Software Test Description
STLDD	Software Top Level Design Document
STP	Software Test Plan
TPI	Technology Planning, Incorporated
VVD	Version Description Document
VRTM	Verification Requirements Traceability Matrix

APPENDIX H

GUIDELINES SURVEY RESULTS

This appendix contains the results of a survey conducted during the interview process concerning the familiarity of the interviewees with the various standards, orders, and guidelines used by the FAA and in particular by the interviewees. Each person was asked to indicate which documents they had used or were familiar with at some level and to indicate on a scale from 1 to 5 their level of familiarity. Most familiar is a 5 and indicates that the person knows the document well enough to explain its use to someone else. Least familiar is a 1 and indicates they know of it but could not explain its usage. A rating of 0 indicates that they did not know of the existence of the document.

The raw results are presented here but no conclusions have been drawn from this data for the following reasons. The sample is too small to be of much significance and the survey was not scientific in nature. The first three interviewees were not asked to indicate their familiarity on the 1 to 5 scale; this was a change in the interviewing process. Their results are indicated under the 'other' column.

If this data appears to be of interest, a more scientific survey should be conducted. The outcomes of such a survey would include indications of:

a. training needs,
b. lack of enforcement,
c. old, unused, and un-needed guidelines,
d. guidelines which are heavily used.

The heavily used guidelines may provide insight as to why some guidelines are successfully used and others are not.

The columns show numbers which are the number of interviewees who had that level of familiarity with the guidelines. For example, the number 4 for DD Form 1423 under column header #5 means that 4 persons indicated a level 5 of familiarity with that item. The TOTAL column indicates the total number of interviewees who responded as knowing that item.

GUIDELINES SURVEY RESULTS

DOCUMENT NUMBER	TITLE	#5	#4	#3	#2	#1	Other	TOTAL*
AC 00-41	FAA Quality Control System Certification Program (for guidance and information)					2		2
AFSC Pamphlet 800-43	Air Force Systems Command Software Management Indicators		1	1		1		3
ANSI Y32.16	American National Standards Institute Reference Designations for Electrical and Electronic Parts				1	1		2
DD Form 1423	Contract Data Requirements List	4		3	1	1	2	11
DD Form 1664	Data Item Description	5	1	3	1		1	11
DoD FAR Supplement 27.410-6					1			1
DoD 5000.19-L, Vol. II AMSDL		1						1
DoD-HDBK-287	A Tailoring Guide for DoD-STD-2167A, Defense System Software Development	1			1			2
DoD-STD-2167A	Defense System Software Development	6	4	2	1		2	15
DoD-STD-2168	Defense System Software Quality Program	3	2	2	2	1	2	12
DoD-STD-480	Configuration Control Requirements	2	3	3			2	10
DOT/FAA/ES-85/03	NAS Training Plan				2	4		6
FAA Order 1100.121a	Management of Air Traffic Control Automation				2	1	1	4
FAA Order 1100.124	AT/AF Responsibilities at NAS Computer Equipped ARTCCs	1	1		1	1	1	5
FAA Order 1100.127b	Airway Facilities Sector Configuration			1	2	2		5
FAA Order 1100.134a	Maintenance of NAS Automation Subsystem	1	1	1	3		1	7
FAA Order 1100.145b	Program Technical Report (PTR) Procedures	7			1	1	2	11
FAA Order 1320.33	Equipment Modification and Facility Instruction			2			1	3
FAA Order 1320.48b	Engineering Field Support Sector Maintenance Program Procedures		1	1			1	3
FAA Order 1370.52b	Information Resources Management - Policies and Procedures			1	3			4
FAA Order 1370.53	Uniform Document Standards							0
FAA Order 1600.2	National Security Information	1		1	2	1		5
FAA Order 1600.40	Security for Electronically Transmitted Messages	1			2	1		4
FAA Order 1600.54	Security of FAA Automated Data Processing Systems and Facilities	1	1		4	2		8
FAA Order 1600.8	Communication Security			1	1			2
FAA Order 1800.25	Configuration Control Support Facility			2	1			3
FAA Order 1800.58	National Airspace Integrated Logistics Support Policy	2	1	2	1	3	1	10

GUIDELINES SURVEY RESULTS

DOCUMENT NUMBER	TITLE	#5	#4	#3	#2	#1	Other	TOTAL
FAA Order 1800.8f	National Airspace System Configuration Management	3	2	1	1	3	1	11
FAA Order 1810.1d	Major Systems Acquisition Management	3	1	1	1	5		11
FAA Order 1810.2	Independent Operational Test and Evaluation for Major Systems Acquisition	2	1		2			5
FA Order 1810.3	Cost Estimation Policy and Procedures	1			1	2		4
FAA Order 1810.4b	FAA NAS Test and Evaluation Program	2	2	5	5	1	2	17
FAA Order 3020.1a	Use of Computer-Based Instruction					2		2
FAA Order 4405.15	Reprocurement Data Acquisition Policy					1		1
FAA Order 4453.2a	FAA Quality Control System Certification Program			1				1
FAA Order 4630.8	Quality Assurance Policy	1			1	1	2	5
FAA Order 4630.9	FAA Computer Software Quality Program Requirements		1	1		3	1	6
FAA Ordor 6000.10	Airway Facilities Service Maintenance Program (inactive)		1	2	2		2	7
FAA Order 6000.30a	Policy for Maintenance of the NAS	1	2		1	2	1	7
FAA Order 6032.1A	Modification to Ground Facilities, Systems, and Equipment in the NAS			2	3		1	6
FAA Order 6100.1a	Maintenance of NAS EnRoute Stage-A Air Traffic Control System	1		2	3		1	7
FAA Order 6100.9c	Quality Control			1	2			3
FAA Order 6120.1a	Facility Modifications to ARTS IIIA Air Traffic Maintained Software	2		1	1			4
FAA Order 7032.2b	Air Traffic Operational Requirements		2	2				4
FAA Order 7800.2D	Program Technical Report (PTR) Procedure	7		1		1	1	10
FAA Order 7800.7b	Costing for Program System Version Updates	1						1
FAA Order 7880.22a	Identification of Source Code Change				1			1
FAA-D-2494	Technical Publications			1	3			4
FAA-STD-002	Engineering Drawings	1						1
FAA-STD-005d	Preparation of Specification Documents	2	4	6			2	14
FAA-STD-013a	Quality Control Program Requirements	2	1	4	2	2	1	12
FAA-STD-016a	Quality Control System Requirements	2	2	4	1	1	2	11
FAA-STD-018a	Computer Software Quality Program Requirements	2	2	4	2	1	3	14
FAA-STD-021a	Configuration Management (contractor requirements)	2	3	3	3	1	1	13
FAA-STD-024a	Preparation of Test and Evaluation Documentation	2	2	4	2	3	1	14
FAA-STD-025b	Preparation of Interface Control Documentation and Interface Requirements Documentation	1	1	3	3	2	1	11

GUIDELINES SURVEY RESULTS

DOCUMENT NUMBER	TITLE	#5	#4	#3	#2	#1	Other	TOTAL
FAA-STD-026	NAS Software Development	4	1	3	2	1	3	14
FAA-STD-028	Contract Training Programs	1		3	2	2	1	9
FAA-STD-030	Preparation of Procurement Request Packages	1	1	3	1	1		7
FAA-STD-031	Preparation of Statement of Work	2	1	2	4	2		11
FAA-STD-034	Instructions for the Preparation of Logistics Support Analysis (LSA) Data	1		2		2		5
FAA-STD-035	Commercial Equipment, Market Research for Preparation of Project Implementation Plans					1		1
FAA-STD-036	Preparation of Project Implementation Plans	1		1	4	1	1	8
FIRMR	Federal Information Resources Management Regulation		1	2	1	4		8
IEEE STD 729	A Glossary of Software Engineering Terminology		1	1	1	4		7
manual	U.S.Government Printing Office Style Guide	1		4	1			6
MIL-H-46855	Human Engineering Requirements for Military Systems, Equipment and Facilities					2	1	3
MIL-STD-1472C	Human Engineering Design Criteria for Military Systems		2	3			1	6
MIL-STD-1521B	Technical Reviews and Audits for Systems, Equipments, and Computer Software	3	1	1	1	1	3	10
MIL-STD-1815A	Ada Programming Language	1	1		2	4	1	9
MIL-STD-2076	Automated Test Equipment				3		1	4
MIL-STD-2077	Test Program Set Development					1	1	2
MIL-STD-2165	Testability Program for Electronic Systems and Equipment			1	1			2
MIL-STD-481A	Configuration Control - Engineering Changes, Deviations & Waivers	1	1	2	2	2		8
MIL-STD-482	Configuration Status Accounting	1			2	1		4
MIL-STD-483	Configuration Management Practices for Systems, Equipment, Munitions, and Computer Programs; 21 March 1979	1		1	3	2		7
MIL-STD-490A	Specification Practices; 4 June 1985	1	1	2	1	1	1	7
MIL-STD-499A	Engineering Management	1		1		1		3
NAS-MD-110	Terms and Definitions for the NAS	2		4		2	1	9
regulation	Federal Procurement Regulations 11.307.1 through 11.307.5	1				1		2
WA 0000.4H	Washington Headquarters Directives Checklist as of February 1, 1989				1			1